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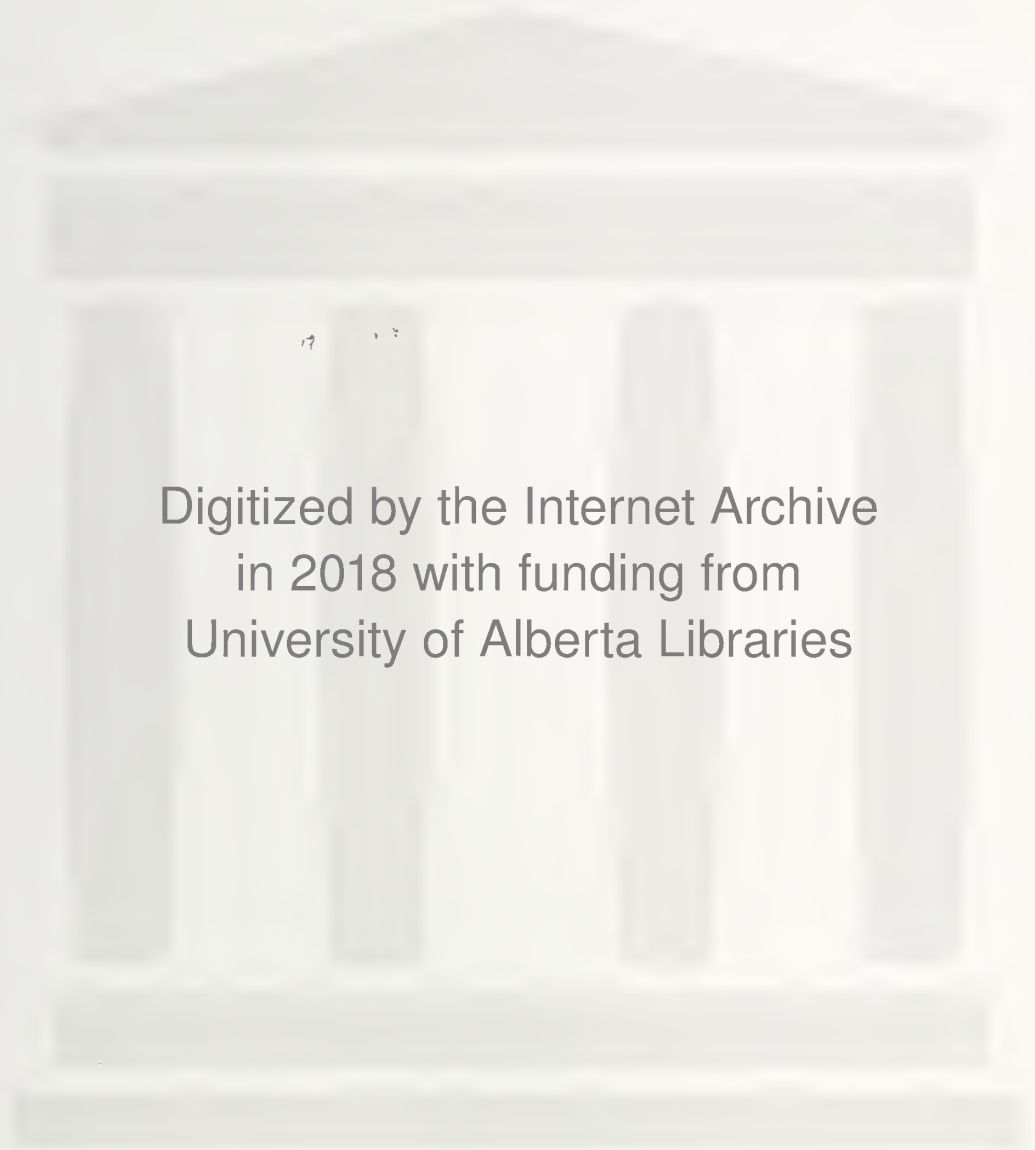
Edmonton, Alberta
April, 1935.



HARVESTING METHODS IN RELATION TO QUALITY IN WHEAT

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By
Donald Cameron.

INTRODUCTION

The development of a large export trade in wheat and increasing competition in the markets of the world have served to emphasize the value of quality in Canadian wheat. More and more, this is the factor which determines whether or not a market once gained can be held, and for that reason the effect of harvesting methods on quality of wheat is one of very great economic importance. The coming of the combine harvester into western Canada in the years 1925-29 served to focus the attention of all concerned on the efficacy of this method of harvesting, particularly from the standpoint of quality. This was only natural because the economy of operation was such as to recommend it, providing it was capable of turning out a high quality of wheat under a wide range of topographic and climatic conditions.

The combine made its first appearance in Alberta in 1925, but, it was in the harvest seasons of 1928 and 1929 that the machine came into wide use within the province. In 1929, the swather and pickup as auxiliary equipment for the combine, made its first appearance, and in the same year the header-barge method which had been previously confined to a small area in southeastern Alberta began to spread to other districts. The harvest seasons of 1930 and 1931 brought about an increase in the use of all three methods of harvesting throughout the wheat growing areas and with this increase interest in their effect on

quality became one of great concern and discussion among farmers and grain men. As a result of this wide-spread interest it was decided to investigate the problem of "Harvesting Methods in Relation to Quality in Wheat" in the harvest season of 1931.

Without special funds and with the very limited facilities available at the University, it was impossible to make an extensive study in the Province in the harvest season of 1931 and this was not attempted. However, through the kind co-operation of Mr. Clyde Gillies, prominent farmer of the Clover Bar district, eight miles east of Edmonton, arrangements were made to carry out some observations on the header barge method of harvesting which was being used on a portion of his crop. The work done in this connection consisted of making a comparison of the commercial grades of grain harvested by the barge and binder methods, a comparison of harvesting losses resulting from the use of the barge and binder methods, and carrying out tests and observations on how barge stacks reacted to varying weather conditions, the latter study being extended to include observations on a few stacks carried over winter.

At the fall meeting of the Grain Research Committee of the National Research Council, held in Winnipeg in November, 1931, it was decided that the scope of the investigation started in Alberta should be extended to cover the three prairie provinces and that the three Provincial Universities should co-operate in the investigation. For this purpose sufficient funds were set aside to permit a detailed comparison of harvesting methods at Clover Bar, and a comprehensive moisture and grade survey throughout the three prairie provinces in the harvest seasons of 1932 and 1933.

LITERATURE REVIEW

The review of the literature will be dealt with in two sections, the first of which will deal briefly with some of the more important factors involved in harvesting which determine the quality of wheat, and second, with the harvesting methods themselves. It might be pointed out at this time that although the literature on harvesting methods, particularly on the combine, is quite voluminous, only a small amount of it deals directly with the question of their effect on quality.

Factors involved in harvesting which determine the quality of wheat.

Quality and condition of wheat at the time of marketing determine the grade and thus influence to a considerable extent the price the grower receives for his product (18). Both of these important factors are influenced by conditions at harvest time, such as stage of maturity, weather conditions, respiration, moulds and fungi (24) (20).

Stage of maturity and moisture content. - Wheat that is cut too green and with too high a moisture content, by any method of harvesting, is likely to spoil either in the stack or in the bin (24) (9). Birchard (7) states that wheat containing any considerable percentage of frosted and green kernels will be likely to heat if it contains 15.5% moisture or over. Immature grain is lower in test weight per bushel than mature grain and the test weight varies with the moisture content (20), decreasing as the moisture content increases. Reynoldson (18) working in Montana, goes on to say that the test weight per bushel of a given lot of grain is an index of the quantity of flour that may be milled from

such grain, and for that reason is an important grading factor because the higher test weights usually return a higher flour yield.

The degree of maturity and moisture content are also important factors in determining the rate of respiration, shrivelled wheat respiring much more vigorously than plump wheat. The respiration curve of the latter rises very sharply with increases in moisture above 14.5% (3).

Moisture absorption. - One of the well-known relationships of the moisture content of wheat is its approximate parallelism to the humidity of the atmosphere (23) and a very good example of the variation in moisture content of standing grain during a single day is shown by Wiant and Patty (26) where the moisture content of a field varied from 20.3% at 8 A.M. to 9.8% at 4 P.M. From this it is concluded by Cox and Boerner (11) that cutting with the combine should not start before 11 A.M. in the spring wheat area and should cease about 15 minutes before sundown. Discussing moisture absorption in stored wheat Stockham (23) stated that all wheats do not respond the same under like conditions, the differences being due to variation in the chemical composition of the wheat itself. He also stated that the amount of moisture wheat will contain at any given time may depend not so much upon existing atmospheric conditions as upon the length of time those conditions have prevailed. Thus, in bulk storage of wheat the rate of change will be dependent on the rate of gas exchange and if the bulk is very great only the surface layer is likely to be affected by atmospheric changes, unless air is forced through by artificial means. Coleman and Fellows (9) exposed all classes of

American wheats to atmospheres of different relative humidities and found that the moisture content increased fairly regularly with the increase in relative humidity until the wheat contained 34.4% moisture in a saturated atmosphere.

The absorptive capacity of wheat is often made use of by the grain trade for the purpose of drying down quantities of wheat known to be high in moisture, and Bailey (1) of Minnesota, quotes an experiment where two lots of wheat were mixed together with an initial difference in moisture content of 5.4%, and three days after mixing the difference was only .7%. In this case the absorptive capacity of wheat for moisture was used to increase the economic value of tough wheat. This same quality may increase the hazard of spoilage in cases where large quantities of green weeds are mixed in, as is frequently the case with combined grain (18) (20) (22). This is clearly brought out in a piece of work by Reynoldson (18) who took two comparable lots of wheat, one at 10% moisture and the other at 13%, and added 10% by weight of green Russian thistle tips, containing 71.6% moisture, to each. Forty-three hours later Lot 1 had increased from 10% moisture to 14.8%, while the moisture content of the thistles had been reduced to 23.2%. In Lot 2 the moisture content increased from 13% to 17.4%, while the thistles had decreased to 32.5%.

That bulk wheat does not dry rapidly even when heating was shown by Birchard (7) when in sampling a car which was heating, he found that the grain contained as much moisture three inches below the surface as it did at the centre of the bulk. No substantial drying had taken place below depths of one or two inches from the surface.

Climatic factors - rainfall, humidity, temperature. - Rainy or cloudy weather may prevent the normal decrease in moisture content of standing grain during the day although the effect of light rain does not last long if clear drying weather follows. On the other hand, if cloudy weather and high relative humidity follows prolonged rainy periods it may take a long time for grain to dry out sufficiently to harvest safely (11) (20). Cox and Boerner (11) in discussing the effect of relative humidity and dew on moisture content and grades of wheat harvested with the combine, showed that the moisture content of standing grain increased from 3 to 6% overnight with the result that grain harvested on the first round of the combine on the following morning had decreased in test weight sufficiently to be reduced one grade. Work done in North Dakota by Benton and Black (6) demonstrated that weathering does not affect the protein content to any appreciable extent, but does have a marked effect in reducing the test weight per bushel even where rainfall has been slight. Constant exposure to alternate wetting and drying or to frost has the effect of expanding the kernels and causing a given volume of grain to contain fewer of them, thereby reducing the yield of flour per bushel (6). Saunders (19) artificially wetted and dried hard Red Fife wheat every day for 8 days to ascertain the effect of repeated wetting by showers in the stook, and found that the test weight decreased steadily with each successive wetting and drying from 61.7 lbs. at the beginning to 56 lbs. after the eighth day.

Bleached and bran-frosted grain is usually graded down because of a reduction in milling yields and deterioration of baking qualities where the effects of freezing have been severe (7) (18).

Sprouting in wheat is a common result of wet weather and high temperatures and is responsible for deterioration in grade and an increase in the storage hazard (6) (20). While it is usually a combination of factors acting at the same time or in succession that causes wheat to go out of condition, temperature is one of the most important of these factors (7). Grain that is stored at a high temperature is much more likely to go out of condition than similar grain of the same moisture content stored at a lower temperature (18).

Coleman and Rothgeb (9) state that the chief causes of heat damage to wheat are unfavorable weather conditions at time of harvesting and faulty methods of handling the crop. High moisture content and high temperature promote mould growth and this is frequently followed by stack-staining and bin-burning (9) (24). Heat-damaged wheat (9) is a product of a number of factors of which temperature is one of the most important. It is one of the most common types of damaged grain found on the market and a small quantity of heat-damaged kernels in a sample is sufficient to reduce the market value very decisively. In this connection Coleman and Rothgeb (9) carried out a series of studies to determine the effect of heat-damaged kernels of various types on milling and baking quality and they found that the addition of very small percentages of heat-damaged or stack-stained kernels had the effect of reducing gluten quality and causing a marked reduction in all other bread-making factors.

Respiration.- The phenomena of respiration plays a very important role in determining the keeping qualities of grain and the rate of respiration is influenced by such other factors as moisture content, temperature, soundness and texture of grain (2)

(4) (24). The moisture content of grain at time of harvesting is very important because of the relationship between moisture content and rate of respiration - the higher the moisture content the more rapid will be the rate of respiration during storage (4). Heat is generated as a result of the process of respiration and as the temperature rises the rate of the reaction is accelerated and unless steps are taken to cool the grain the heating process will be carried on until stack-staining or bin-burning results (4) (9). Green (14) says that combined wheat will be seriously damaged as far as its milling quality is concerned if its temperature goes over 100°F. in the presence of 14 or 15% moisture.

Moulds and fungi. - Under favorable conditions of high moisture and high temperature moulds will develop in grain that is heating in the stack or bin with very deleterious results on the milling and baking quality (9) (24). The growth of moulds increases the production of heat by increased respiration in the grain and causes severe damage in addition by destroying wheat tissues. Fungi have been mentioned as actively developing in damp wheat in a piece of work done by Bushwald in Germany in 1916 and described by Bailey (1). The most important of these fungi were Aspergillus glaucum and Penicillium crustaceum, and they were only found developing in wheat containing over 16% moisture.

Effects of physical and chemical changes. - The changes which wheat undergoes during the sweating and curing process in the stook, stack, or bin are reflected in improved baking qualities (24) which are clearly indicated in a piece of work by Fitz (13). According to this work the most important of these improvements is an increase in the water-absorbing capacity of the flour and an increase in the loaf volume of the bread. As the wheat underwent

the natural process of aging the gluten became more elastic and pliable, dough was more easily handled and required less fermentation, and gave a loaf of larger volume and better texture, although the bread made from new wheat had the highest color score (13). Swanson and Fenton (24) observed that from the milling and baking standpoint a certain amount of respiration in storage improved the quality of newly-threshed wheat. They point out that until wheat goes through a certain after-ripening process the quality is not at its maximum and until the maximum is reached there is a general improvement. This improvement is generally considered to continue throughout the first year of storage and the baking quality is maintained with little change in loaf volume, texture and score of bread for five or six years. After this time there is a decided falling off in loaf volume and texture (13).

Harvesting methods.

The literature reviewed in this section will deal with the relation of the binder, combine, swather and combine, and header barge methods to (1) moisture content and (2) quality of grain as determined by commercial grade and milling and baking tests.

Binder

Moisture content at harvest time. - The proper time to cut grain with a binder in order to secure the best quality from the standpoint of grade and weight per bushel varies with different localities and individuals. Schwantes (20) says that cutting should be done at about 30% moisture, while Swanson and Fenton (24) put it at 30 to 35%. Benton (6) says wheat is usually considered ripe when it contains from 20 to 25% moisture although in the case of unevenly ripened fields it may be much higher. Because binder cut

grain has an opportunity to cure and dry in the stook there is usually very little complaint against it in normal seasons from the standpoint of moisture (12) (6). When seasons are unfavorable no method is entirely satisfactory (9) but there is likely to be less loss through spoilage and bleaching in well-built stooks than with other methods of harvesting (6) (7). The binder method is well adapted to humid conditions (7) but if wet weather is prolonged spoilage may take place in the stook through sprouting and bleaching (7) (20). Similarly, if wheat is threshed from stooks before it has time to cure or too soon after rains it will spoil just as readily as wheat harvested by other methods (18).

Moisture and grade. - In a field survey made in western Canada in 1932 Larmour (16) found that the average moisture content of binder harvested wheat was lower than the average for either combined or swathed grain. With respect to the effect of the binder method on quality as measured by commercial grade the same authors were able to show that the binder harvested samples had a higher average grade than swathed or combined grain.

Combine

Moisture content. - Reynoldson (18) carried out an investigation in Montana on the moisture contents of wheat harvested by different methods and his results showed that combined wheat had a higher average moisture content than grain cut with the header, and that the maximum moisture contents of the samples were higher. Similar results were obtained by Benton (6) in North Dakota, and by Larmour (16) in western Canada.

Factors contributing to high moisture content. - One of the main contributing factors is cutting before the wheat is dead ripe.

Binder harvesting starts at moisture contents which vary from 20 to 35% (6) (20) (24). From this it follows that grain that is to be combined must stand for a period after binder harvesting starts before it reaches a moisture content of 14% at which it can be safely combined. This period varies from 7 to 21 days according to the locality and weather conditions prevailing during the interval (6) (20) (25). In thick stands of unevenly ripened or lodged grain an even longer period may be required.

The second important factor is combining too soon after rain, dew, or during a period of high humidity, and in this case Benton (6) gives an instance where a heavy rain raised the moisture content of a field of wheat from 12% to 26.6%, and five days elapsed before the grain returned to 14% moisture (11) (23).

A third important factor contributing to the high moisture content of combined wheat is that of starting to combine too early in the day. Miant and Patty (26) described the variation in moisture content in a field as varying over 10% between 8 A.M. and 4 P.M. on the same day. Similar results were recorded by Cox & Boerner (11) who concluded that as a rule combining should not start before 11 A.M.

A fourth factor contributing to high moisture content is the presence of green weeds in standing grain and the importance of this factor is clearly demonstrated by the work of Reynoldson (18) previously cited, where absorption of moisture from green Russian thistle tips caused a dry sample of stored grain to become tough. Similar results are quoted by Schwantes (20) and Reynoldson (18).

Quality of dry combined wheat. - Up to the present time the

combine has been designed primarily for large scale farming under comparatively dry conditions, and when used under these conditions the wheat harvested by the method shows no appreciable difference in quality to that harvested with the binder (18). Benton and Black (6) and Reynoldson (18) state that the method used in harvesting and threshing does not influence the quality of the grain and that dry combined wheat, free from spoilage, is equally as desirable as binder wheat. They do point out, however, that there is a danger that wheat may be combined when not in proper condition.

Taggart and McKenzie (25), in discussing grading of combined wheat in Saskatchewan, say that when proper precautions are taken about the time of commencement of combine harvesting, and due allowance made for the effect of dews and showers on standing grain, there is no good reason why combined grain should grade lower than binder-harvested grain. They also state that grain combined late in the season will invariably be graded down on account of bleaching. No significant differences were observed by them in milling and baking quality between binder-harvested and combined grain, although in one season the combined sample was slightly superior.

Effect of storage on quality of combined wheat. - In discussing storage of combined wheat Swanson and Fenton (24) say that damage to quality will result from storing combined wheat at a moisture content sufficiently high to cause heating which is usually accompanied by moulding. Heating alone may damage the wheat but greater injury will result when the heating is accompanied by mould growth. Continuing, they say that natural

respiration in normally dry combined wheat brings about an improvement in the baking value of the flour.

Swather

The swather and pickup has extended the zone of usefulness of the combine into areas of higher humidity and more uneven topography than those where the combine itself works efficiently, but its main value is in cutting fields which contain a large number of green weeds. These weeds if combined with the ripe wheat would contain sufficient moisture to cause it to go out of condition in storage, but if laid in the swath they will dry in a few days and permit the grain to be picked up and combined safely (6) (26).

Rate of drying. - Schwantes (20) studied the effect on rates of drying, of cutting stubble at heights of 9 to 15 inches, and found there was no appreciable difference. He also made a comparison between the rate of drying of swathed and standing grain and came to the conclusion that there was very little difference, standing grain drying from 30% moisture to 14% at approximately the same rate as that in the swath. McKenzie (17) made similar observations at Swift Current and stated that contrary to a very general belief held by many farmers, the swather and pickup method of combining does not permit grain to be threshed earlier than if straight combined, except in the case of very weedy fields.

Grade. - Wiant and Patty (26) compared heavy and light swaths under exposure to heavy rains and found that the heavy swath was borne up well on the stubble and contained very little sprouted grain, while the light swath worked down through the

thin stubble and a lot of the heads sprouted. Under similar weather conditions swaths dried out more rapidly than grain in the stook but there was a considerable amount of bleaching (20).

In a moisture and grade survey in western Canada in 1932 Larmour (16) reported that swathed samples were on the average inferior to samples harvested with the binder and combine methods from the standpoint of grade.

Barge

The header barge method simply consists of elevating the headed grain into a large box or barge which is attached to and pulled as a unit with a binder, header, swather, or combine platform (21). Another machine performing the same function and called the New Way Harvester is simply a tractor-operated header barge (15).

Moisture content at time of cutting. - Speaking of the proper time for cutting wheat with the barge Smith and Cameron (21) say that a general guide would be to harvest at normal binder harvest time when the moisture content will usually be under 35%. McColley in North Dakota (15) mentions 30% moisture as the best time to barge in order to secure the maximum test weight per bushel. He indicates that this is at what is called the firm dough stage of wheat. Grain that is cut greener than this is likely to suffer a loss in test weight per bushel and one example is quoted where a field barged at 50% moisture in the unthreshed sample and 36% in the grain, suffered a reduction of 5 lbs. per bushel in test weight.

The length of time the grain will need to remain in the stack before threshing will depend upon the moisture content at time of cutting, the amount of green weeds included with the grain, and the weather conditions prevailing during the period. Subject to these conditions the time varies between 7 and 30 days (15) (21) (25).

Taggart and McKenzie (25) in Saskatchewan, cut one field badly infested with green pigweeds, at a moisture content of 48.34% and three weeks later the stacks were threshed at a moisture content of 14.4%.

The weather conditions during the early curing period and the type of stack built will influence very markedly the final quality of the grain from a grade and milling standpoint (15) (9) (27). If crops are stacked too green and a period of wet weather ensues some spoilage in the stack may be expected, but if the weather is moderate a high quality of grain may be produced (15)

During the wet season of 1928 McColley (15) states that many barge stacks were left in the field over winter and threshed satisfactorily in the spring. Smith and Cameron (21) report that stacks in central Alberta were exposed to 5 inches of rain in the harvest season of 1932 without sufficient spoilage to affect the grade. Stacks must be built high in the centre from the bottom to the top of the stack in order that moisture will drain to the outer surface of the stack and it is usually considered good practice to send a man around the fields occasionally to replace stack tops which may have blown off (21) (27).

Effect of curing process on quality. - During the curing process the grain goes into a sweat (15) within about 48 hours after placement and this process is generally agreed to be beneficial from the standpoint of giving the grain a good color and preventing shrivelling. Grain in barge stacks is not subject to bleaching to the same extent as grain in the swath or stook (15) (25). When barge stacks go through the curing process in a normal manner the quality of grain from the standpoint of test weight and commercial grade is likely to be equally as good as that harvested by other methods (15) (21) (25). On the other hand, if the grain is cut too green, or if rain penetrates the stack, or both, heating, moulding and stack-staining are almost bound to result causing a very marked deterioration in grade and milling and baking qualities (9) (24).

EXPERIMENTAL

A Comparison of Harvesting Methods in Relation to Quality in Wheat and Barley During the Fall of 1931.

As was pointed out in the introduction, this problem was suggested late in the fall of 1931 and at a time when much of the grain had been harvested. This made it difficult to secure comparable samples of wheat. Added to this was the further difficulty of inadequate funds and materials with which to carry out an extensive investigation. The work actually accomplished in the harvest season of 1931 was to carry out a limited comparison of methods of harvesting at Clover Bar on (a) effects of harvesting methods on quality of wheat, (b) over-wintering of barge stacks, and (c) a comparison between harvesting losses resulting from the barge and binder methods. Through the kindness of Mr. Clyde Gillies of Clover Bar, it was arranged that these studies should be carried out on his farm, located 8 miles east of Edmonton.

Methods

Observations were carried out on a 60 acre field on the farm of Mr. Gillies. The land was slightly uneven and rolling with a gradual slope to the west. The soil was Edmonton black loam. Part of the field was sown to Marquis wheat and the balance to O.A.C. 21 barley.

Weather. - The harvest season of 1931 was not a favorable one and frequent rains and heavy dews at night delayed cutting for some time after the normal cutting date. The actual amount of rainfall recorded between August 10th and October 15th was 2.63 inches. From this it will be seen that barge stacks and stooks were both exposed to more than the average amount of rain after placement.

Condition of grain. - As a result of delayed cutting the grain was more uniformly mature than usual. Green spots in the

depressions had had an opportunity to ripen, consequently there was little variation in maturity over the whole field. There was practically no second growth and the only weeds were stinkweed and wild oats which had matured long before harvest time. Heavy rains during the late harvest season had delayed cutting and caused the grain to become very badly lodged.

Equipment used. - The equipment used consisted of a No. 4 Frost and Wood 7 foot binder. The same machine was used to head the grain by the simple expedient of removing the binder head, putting an extension elevator on it, and raising the cutting table as high as the lodged condition of the grain would permit. Rollers on the extended elevator were lagged with two inch, four-ply belting for the double purpose of speeding up the rate of travel and narrowing the space between the canvases to prevent loss of grain.

The barge used was a home-made box-like structure approximately 6'6" X 6'6" X 6'6", mounted cart fashion on a two wheeled truck. The outfit was pulled by five horses hitched separately - two on the barge and three on the binder or header. For threshing, an ordinary 22" X 32" Advance-Rumely separator, powered with a Fordson tractor, was used.

A home-made sweep rake, operated by one man and two horses, was used to bring the barge stacks in to the separator. Where the maximum haul was not over 200 yards this outfit could keep the separator supplied with grain. No extension feeder was used on the separator although this would have made feeding the machine easier.

Method of harvesting. - Owing to the lodged condition of the grain it was necessary to set the binder as low as possible. Heading was out of the question and this made it necessary to take a great deal more straw than would have been necessary or desirable under

other circumstances. The seven foot binder delivered the grain into the barge at such a rate that it was necessary to have two men in the barge, stacking. After the stack was unloaded one of the men remained behind to top it off before going into the barge again.

Comparable portions of the field were selected and alternate swaths cut and stooked with the binder and header barge, the cutting all being done the same day. After several of these alternate swaths had been cut, the balance of the field in each case was divided and cut in approximately equal proportions with the binder and with the barge. In the case of the barley, particularly, it should be mentioned that the heads were doubled over almost to the ground. This meant that quite often the same straw was cut twice and the head dropped to the ground and was lost.

As much of the grain had been cut before the writer was able to start on the project, no moisture tests were made on the grain at time of placement. In view of this fact it was decided simply to make periodic observations on the barge stacks for heating and sprouting and to compare the commercial grades of grain harvested by the two methods. In the case of wheat, milling and baking tests were also made in the University laboratory and the results are shown in Table I.

Both wheat and barley stacks were exposed to heavy rains after cutting and the barley was cut during a period of showery weather and the stacks were placed on damp ground as a result.

Results

Barley. - There was no indication of severe heating at any time in the barge stacks although a certain amount of moulding took place in some spots in the stacks. This appeared on the straw and glumes giving some of the grain a somewhat musty smell. The mould

appeared to be all knocked off in threshing and there was not a sufficient amount of moulded or musty grain to affect the bulk sample, either from the standpoint of appearance or odor. In some of the stacks a certain amount of sprouting took place in the bottom layer to a depth of six inches. Although exposed to heavy rains the stacks did not take water in spite of the fact that it was very difficult to build a good stack with such long straw in a small barge. The threshed sample from the barge stacks graded 3 C.W., being lowered a grade on account of the occasional sprouted kernel which came from the bottom layer of the stacks, and to the fact that the grain was somewhat discolored owing to the delayed cutting.

The barley in the stooks was exposed to severe weather before being threshed with the result that there was a small amount of sprouting and some severe discoloration. The stooks were threshed before the barge stacks and yielded a commercial grade of 3 C.W., the same as the grain from the barge stacks. In the opinion of the official government grader, the barley from the stacks was a superior 3 C.W. to that from the stooks, having a brighter color and a more uniform appearance. This difference in color was probably the outstanding difference in the samples and it could be directly attributed to the fact that a larger proportion of the grain was not exposed to the weather, and probably to some extent to the effect of sweating in the stack. The fact that the barge stacks required a longer time to dry out after a rain than the stooks did may be attributable in part to the large amount of straw which had to be cut and stacked, thus preventing a good circulation of air, and in part to a larger physical bulk of material than in the stook. On the other hand, the fact that the stacks did not take water to any appreciable extent is

an indication that if properly made and topped, barge stacks can withstand very severe weather conditions quite satisfactorily.

Sprouting in the bottom layer of the barge stack is an almost inevitable result of starting to cut too soon after a rain. This would indicate that the best time to start barging after a rain depends not only upon the fitness of the grain itself but also upon the relative dryness of the soil on which the stacks are to be placed, and that, if loss is to be avoided, barging should not start until the soil is quite dry. This is likely to mean that the grain will be ready to barge before the soil is ready to place the stacks on it, and the heavier the rain the longer it will be necessary to wait.

Moulding in stacks is quite a common occurrence and is due to high moisture content of the straw and to poor circulation of air. Experience has shown that unless moulding is associated with severe heating and stack-staining it has very little effect on the commercial grade,, all or most of it being knocked off in threshing.

Wheat. - The wheat was cut under more favorable weather conditions than the barley. The weather was drier, the wheat was not as badly lodged, and it was fully mature and dry when placed on dry ground. It was possible to take less straw than in the case of the barley, with the result that stacks were better built and more porous, thus permitting a freer circulation of air. There was practically no sprouting in the barge stacks except in those cases where stacks were placed on low, damp ground. In these cases a few stacks were to be found growing to the ground on the north side.

Moulding in the stacks was almost negligible and there was very little difference in the time in which the barge stacks and stooks were ready to thresh. The threshed grain from the barge stacks

graded a strong 1 Northern while that which was threshed from the stooks was just a fair 1 Northern. The difference was mainly due to a superior color in the barged grain which was brighter and more uniform than that obtained from the stooks. The stooked samples showed quite a lot of bleached kernels and consequently did not have the same uniform appearance. There was no appreciable difference in the test weights between the two samples.

A comparative analyses of the samples taken at time of threshing and two months after threshing is shown in Table I. In each case representative samples were taken of the bulk lots of wheat harvested by the two methods.

Table I

Comparative analyses of samples harvested by binder and header barge methods, 1931.

Method of Harvesting	Sample No.	Time of Sampling	Grade	% Moisture	% Protein	Wt.per Bu.
Binder	HA8	At time of threshing	1°	8.38	16.8	65.0
Barge	HB4	" " " " After 2 Months' Storage	1°	8.48	16.4	65.0
Binder	HA4	2 months after threshing	1°	12.7	16.4	63.5
Barge	HB3	" " " "	1°	11.93	16.6	63.5

The above samples were stored in air-tight tins in the laboratory until the spring of 1932 when they were milled in the University laboratory and the results of the milling and baking tests are shown in Table II.

Table II

Results milling and baking tests, binder and barge samples, 1931.

	Basic formulae				Bromate formulae			
Lab. Nos.	HA8	HB4	HA4	HB3	HA8	HB4	HA4	HB3
Straight flour	66.6	67.2	66.0	67.3	66.6	67.2	66.0	67.3
Total flour	73.6	74.1	74.0	74.5	73.6	74.1	74.0	74.5
Absorption	69.2	75.3	71.4	75.2	69.2	75.3	71.4	75.2
Color crust	4.5g	5.	5.	5.	5.	5.	5.	5.
Form	5.	4.5f	4.5s	4.5f	4s	4s	4s	4s
Color crumb	7.g	7.g	6.5g	6.5g	7.g	7.5g	7.g	7.g
Texture	7.c.o.	7.c.o.	7.c.	6.5c.	8.	7.o.	7.5o.	8.
Loaf volume	662	716	694	718	825	797	750	758

Discussion of results

The harvest season of 1931 in the Edmonton district would be described as slightly below normal as far as harvesting conditions were concerned, there being quite a lot of rain interspersed with a considerable amount of showery and misty weather. Under these circumstances it must be considered that the barge stacks of both wheat and barley proved themselves capable of producing a grade of grain equal to or better than that harvested by the binder. Barley stacks required a longer period to dry out after rain than barley stooks and did not dry out as readily as wheat stacks. This may be attributed to the fact that the barley straw was softer, there was more of it, and it packed together more closely in the stack thus preventing as free a circulation of air. The grain going into the stack in both cases was fully mature and comparatively free from green weeds and these were undoubtedly very important factors in permitting the stacks to withstand the wet weather as well as they did.

Moulding in the barley stacks, although insufficient to have any effect on grade, was present in sufficient quantities to indicate that in less mature grain it might be a cause of deterioration. Wheat stacks exposed to practically the same conditions exhibited very little

sign of moulding and as a result it might be concluded that barley is more susceptible to this form of damage. Sprouting of a small amount of grain on the ground on the north side of the stacks is an almost inevitable result of placing stacks on damp ground. Stacks placed on dry ground did not exhibit this tendency.

Reference to Table I will show that there was no significant difference between the moisture, grade, or weight per bushel of wheat harvested by the two methods at time of threshing in the fall. Samples were again taken as the grain was being sold from the farm granary two months later. These samples were taken from each load as it was being hauled away, and stored for a time on the granary floor in sacks and this may account for the higher moisture content and decreased weight per bushel of the latter samples.

The results of the milling and baking tests shown in Table II do not show significant differences except in absorptive capacity of the barge samples which were higher in this respect than the binder samples. The barge samples had the largest loaf volume with the basic formula but with the bromate the binder sample taken at time of threshing gave the largest volume and the two samples taken after two months' storage showed no significant differences with the bromate bake which is the fairest test of the two.

Conclusions

While it is not safe to base conclusions on such a limited study certain tendencies are at least in evidence and these might be summarized as follows:

Grain that is fully mature when placed in properly made barge stacks will withstand a lot of wet weather without serious difficulty, but the stacks may require a longer period to dry out than similar grain in the stook. Barley stacks will require longer to dry than

wheat and are more susceptible to moulding and should not be barged unless fully mature.

Over-wintering of barge stacks

In order to study the effect of weather conditions on stacks during the winter months, two wheat stacks and one barley stack were carried over the winter of 1931-32. Beginning on the 23rd of March, 1932, the wheat stacks were sampled for moisture and grade, at intervals of approximately two weeks, for a period of three months. The weather during the winter had been that of a normal Edmonton winter with about 48 inches of snow which was practically all gone on March 23rd. Samples were taken by opening the top of the stack and using a hook which was shoved into the stack at various levels and then pulled out bringing with it heads and straw. This material was immediately placed in air-tight containers and taken to the University where it was threshed and moisture tests run on the grain and straw. Moisture determinations were made by drying at 100°C. for five hours, then grinding and drying at 130°C. for one hour. The results of these tests are shown in Table III.

Table III

Moisture and grade determinations made on barge stacks of wheat carried through winter of 1931-32.

Sample No.	Date of Sampling	Atmospheric Temp. 3 p.m.	% Rel. Hum.	Grade	% Moist. Threshed Sample	% Moist. Unthreshed Grain	Rainfall since last sampling	% Protein
1	Mar. 23	54°F.	42	1°	19.34	17.03		16.1
4	Apr. 5	45.5°F.	41	1°	18.55	17.27	Trace	16.2
# 5	Apr. 5	45.5°F.	41	1°	18.58	-----	"	16.2
7	Apr. 14	61°F.	42	1°	14.51	13.10	.16	16.3
9	Apr. 29	56°F.	37	2°	19.40	17.85	1.40	16.0
11	May 3	67°F.	29	2°	16.8	16.1	Trace	----
13	June 21	76°F.	31	4°	20.3	19.45	3.73	----
14	June 21	76°F.	31	4°	19.75	19.2	3.73	-----

Note: Sample No. 4 contained percentage of weed seeds. These were removed in Sample No. 5.

At the time of placement the barge stacks were about six feet high. By March 23rd they had settled to about 4'6". The stacks were in good condition and did not show any effects of rain penetration or snow water. Prairie chickens had done some scratching on the tops of the stacks and a few mice were nesting in the lower portions. The ground underneath the stacks was dry and dusty and there was no indication of sprouting or moulding in any part of the stacks. Grain and straw were tough from moisture absorption from the atmosphere but both were bright in color and the sample graded 1 Northern.

From Table III it will be seen that the stacks were in good condition to thresh on April 14th and could have been threshed at that time. However, it was decided to carry the stacks still further and to observe the effects of heavy summer rains. Between April 14th and 29th the stacks were exposed to 1.40 inches of rainfall with the result that the moisture content had increased appreciably, some of the grain had become discolored and some sprouting had taken place, with the result that the sample graded 2 Northern damp. Between April 29th and May 3rd a trace of rain was recorded and the stacks had dried down to some extent although the straw on the north side near the bottom was quite wet. Some of the grain was showing a darker color and the grade was still 2 Northern.

From May 3rd to June 21st the stacks were exposed to very heavy summer rains and 3.73 inches were recorded. The week preceding June 21st had been dry and warm and it was decided to thresh the stacks. During the interval between May 3rd and June 21st quite a lot of sprouting had taken place on the top of the stacks and on the north side. Some of the kernels had turned a dark mahogany color, thus indicating local pockets of heating and stack staining.

The bulk sample had a very poor color due to the large proportion of heat-damaged and sprouted kernels. In spite of this, however, it was interesting to note that the grain in the centre of the stack was still dry and of good color.

Discussion

This experiment would indicate that in the case of larger stacks where a smaller proportion of the total grain was exposed to the weather, properly built stacks would stand very severe weather without serious loss, and it also indicated that if barge stacks are properly built they can be carried over winter and threshed early in the spring without any appreciable loss. The barley stack which had been held over was not tested for moisture and grade because it became evident earlier in the season that it had not come through the winter as well as the wheat. Mice and prairie chickens had played a part in opening the stack up and it was also badly drifted over with snow. On June 21st when the wheat stacks were threshed the barley stack was largely spoiled and growing together in such a manner that nothing could be done with it.

Conclusions

As was stated previously, it would appear that properly built barge stacks of dry, well-matured wheat can be carried over winter without fear of loss. Barley stacks are more subject to spoilage and the practice of carrying them over should not be encouraged.

Comparison between the harvesting losses resulting from the barge and binder methods, 1931.

A small experiment was conducted in the late fall of 1931 for the purpose of making a comparison of harvesting losses between the header barge and binder methods, the quadrate system of estimating results being used.

Methods

After the fields had been cut and threshed the author went into the field and, using a quadrate one yard square, made field counts of the amount of grain left lying in the field. Counts were made by throwing the quadrate over the shoulder and making a count of the grain found lying on the ground within the space where it fell. Shattered kernels were carefully picked and placed in a separate bag for each square yard, which was labelled "Kernels, Plot No. 1," etc. Shattered heads were gathered and placed in another bag which was labelled "Heads, Plot No. 1," and so on. A minimum of ten counts was made on each field and after this was done the samples were taken into the laboratory where the heads were threshed and weighed. The kernels gathered on each yard square were also weighed separately in order that a comparison could be made which would determine in what form the loss was taking place, as shattered heads or shelled kernels. The grain threshed from the heads was added to the shelled kernels to give the total loss per square yard, and the average of ten replicates gave the average loss per yard, and from this it was not difficult to arrive at the loss per acre.

The barley field was so badly lodged and the loss was so high that no attempt was made to segregate the loss into loss as shattered kernels and as heads. The whole amount was simply bulked together to give the total loss per square yard.

Counts were made on stook bottoms and on barge stack bottoms but the losses recorded in these places have not been added to the field counts for the reason that the number of stooks and stacks per acre varied from place to place, some fields having 100 stooks per acre, others 75 and others over one hundred. The number of barge

stacks per acre will also vary with the size of barge being used, the amount of straw being cut, and the degree of packing in the barge.

Results

The results of the comparison of harvesting losses are shown in Table IV.

TABLE IV

Comparison between the harvesting losses resulting from barge and binder methods, 1931.

Method	Crop	No. Counts per Field	Loss in shattered Kernels		Loss in shattered Heads		Total Loss Bus. per Acre.
			Ozs. per sq. yd.	Bus. per acre	Ozs. per sq. yd.	Bus. per acre	
Barge	Marquis Wheat	10	.18	.87	.26	1.3	2.17
Binder	Marquis Wheat	10	.37	1.8	.67	3.3	5.17
Barge	Barley	10					9.7
Binder	Barley	10					11.3

Losses under 10 stook bottoms in the same field of wheat averaged 2.07 ozs. per stook. The average area covered by each stook was 3 square yards. On the basis of 100 stooks per acre, a loss of 2.07 ozs. per stook would give a total loss of .21 bushels or 13 lbs. per acre. The average area covered by the barge stacks was 9 square yards. Counts were only made on two stack bottoms and the losses worked out at an average rate of .065 bushels per acre, where there were two barge stacks per acre. From this it will be seen that there is not only less loss through shattering during cutting when the grain is barged, but there is a much smaller loss around the barge stack bottoms, than around stooks in a field of equal area.

Discussion

It will be observed that there was a heavier proportion of the

loss accounted for as shattered kernels when the binder was used than when the barge was used. This is no doubt accounted for by the fact that in the header barge the packers and binder head mechanism are removed, thus eliminating a certain amount of shattering. Another cause of shattering in binder harvesting is the jar received by the sheaf as it falls on the bundle carrier. The amount of shattering in this case will depend on the ripeness of the grain and the variety. In case of grain cut at the proper stage the loss will not be heavy. In the case of over-ripe grain the loss may be significant.

One rather interesting result of the study is the disclosure of where most of the loss takes place. A common belief among farmers is that most of the loss takes place under stook bottoms. The results of this brief experiment would indicate that this is not so and that the most important source of loss is in the kernels and heads which are shattered as the machine moves over the field.

This study serves to emphasize the importance of growing varieties of grain that do not shatter easily because the loss per acre would be appreciably higher than with a non-shattering variety. It also emphasizes the importance of timeliness of cutting. The grain in the fields studied had become somewhat over-ripe during a period of unfavorable harvest weather and this no doubt was responsible for increasing the percentage loss. The unusually high loss in the barley is accounted for by the fact that the grain was badly lodged and twisted, many of the heads being bent over so as to almost touch the ground, with the result that the same straw was often cut twice and the head fell to the ground and was lost. It should also be noted that when grain, and particularly barley, is in the condition this field was in, it is almost impossible to make a good sheaf

with the result that many heads are broken off and lost as the grain is handled.

This particular study is interesting also because it shows the actual form in which the loss is taking place. Previous workers may have done the same thing but have not recorded their findings in the same way with the result that it has been impossible to tell where the bulk of the loss was taking place and whether in the form of shattered heads or kernels. The losses under stook bottoms in the field will depend to some extent on how well the sheaves have been tied, the uniformity of the stand and upon the relative thoroughness with which field pitchers clean up the loose material. Some pitchers make a practice of picking up the loose material and others do not. In the field under study a reasonably good job had been made of cleaning up under the stooks, and this is borne out by the comparatively low loss.

Conclusions

While the survey of losses was too limited to be of much significance it does indicate that the loss from shattering is more serious than the average farmer is inclined to think. Good farming practice through the use of suitable non-shattering varieties and cutting at the proper stage will reduce the amount of loss. The study also agrees with the work of McColley (15) in North Dakota, and Schwantes (18) in Minnesota, that harvesting losses are appreciably less with the header barge than with the binder and stook method.

Comparison of Harvesting Methods and Their Effect on Quality of Wheat, 1932.

Introduction

Owing to the fact that the Grain Research Committee of the National Research Council made a grant for the purpose of studying the effect of harvesting methods on quality of wheat, it was possible to carry out detailed studies in the harvest season of 1932.

Early in the summer arrangements were made with Mr. Gillies of Clover Bar, to carry out these experiments in a 60 acre field adjoining the one in which the observations were made in the fall of 1931. This field was not as uniform as desirable, being somewhat rolling with a gradual slope to the west, but it was the best obtainable under the circumstances. One portion of it was sown to Marquis wheat on stubble and this was designated Field No. 1. The other portion was Marquis wheat on fallow and designated Field No. 2.

Arrangements were made to harvest these fields in four ways, namely, with the swather and combine, straight combine, binder, and header barge. In order to make sure that the grain harvested by these methods was representative it was arranged to divide the fields into sixteen, approximately equal strips of four replicates each. When it came time to harvest the grain however it was found more practical to divide the fields into eight strips instead of sixteen, thus having two replicates of each method instead of four.

The studies at Clover Bar were undertaken as part of a series of investigations in the three western provinces on the effect of the method of harvesting on the moisture content and grade of

wheat, but in this particular case the study was extended to include a comparison of the milling and baking properties of wheat harvested by the various methods.

The weather during the harvest season was almost ideal and in marked contrast to that which obtained in 1931. During the whole period of the experiment which extended from August 25th to September 18th, only 0.17 inches of rain fell, something quite unusual for the Edmonton district.

Methods

The equipmentused in harvesting the binder and barge samples was the same as that used in 1931, with the exception that the barge had been rebuilt and extended one foot in length, making it 7'6" long instead of 6'6". A 16-foot McCormick-Deering swather was hired and a 12-foot Holt combine and pickup was loaned by the Peace River Tractor Company of Edmonton.

It should be pointed out here that the type of barge equipment used in this experiment is not satisfactory. Because of the limited range of cutting height of a binder more straw has to be included in the stack than is the case where a header, or binder converted to function as a header, is used. With the large amount of straw that it was necessary to cut with the binder, the barge was too small to permit the most efficient stacking to be done, because the straw was elevated into the barge so fast that two men were required to keep it away, and the difficulties of two men working in a barge of the size used are rather obvious. More suitable equipment was not available and in order to overcome the handicaps imposed by it, more than ordinary care was given to building the stacks and topping them off after placement.

As was mentioned previously the land was rolling and uneven but was divided in such a way that the grain harvested by each method would be comparable. Field No. 1 was Marquis wheat sown on stubble land, the second crop after summerfallow; Field No. 2 was Marquis wheat on fallow. Field No. 1 did not ripen uniformly, there being a small percentage of secondary stalks which were quite green while the rest were dead ripe. The moisture range of individual heads selected at random in the field at time of cutting varied from 17.8 to 41.2%, the average being 25.9%. The straw was, in general, short and dry and on the higher ground quite thin. Combining in this field was carried out when the grain reached a moisture content of 14.2%.

Field No. 2 was a much heavier stand than Field No. 1 and the ripening was much more uniform, the moisture range of grain from individual heads in the standing crop at time of cutting being from 21.7% to 30.7%, the average being 23.64%. Harvesting was 12 days later than in Field No. 1, and the average moisture content at this time was 23.64%. Combining was carried out at a moisture content of 13.9% and the combined grain was bulked in a bin as it was hauled from the combine, and studies carried out on it to determine temperature and moisture changes for a period of 12 days after threshing. No attempt was made to study changes in storage of grain harvested by other methods.

Sling psychrometers were used for securing air temperature and relative humidity readings and stick-type maximum thermometers used for temperature readings in barge stacks and grain bins.

Moisture determinations. - All moisture determinations were

made in the same way; the practice followed was to go out in the standing crop selecting upper and lower heads alternately at different places in the field until approximately 80 heads were gathered. Random selections were made from swaths and stooks in the same way. The heads were placed in air-tight cans, taken to the laboratory, threshed immediately, dried at 100°C. for five hours, then ground and dried again at 130°C. for one hour.

In the case of barge stacks, samples were taken at intervals after placement over a cross-sectional area, at one foot from the top, at three feet from the top, and one foot from the bottom, in stacks that averaged about 5'6" in height when settled. Where moisture tests were made on binned grain, samples were taken from different places and different levels in the bin.

Temperature and humidity. - Temperature and humidity readings were taken with a sling psychrometer at as near 3 P.M. as possible each day and the values recorded are for that time. In studying temperatures in barge stacks maximum thermometers were used. These were left in the stacks for 1½ hours and then the readings taken. Temperatures of binned wheat were recorded by placing stick thermometers in the bin at the centre, and six inches from the bottom of the bin. They were left in the grain only being removed to record the readings and lower the mercury columns.

Grades. - All grading was done at the Edmonton office of the Western Grain Inspection Division, hence all grades are official.

Protein. - Total nitrogen was determined by the Kjeldahl method using mercuric oxide as the catalyst. Nitrogen values were converted to protein using the factor 5.7 and corrected to

the basis of 13.5% moisture.

Baking. - The basic and bromate formulae were used, the latter including 1 mgm. of $KBrO_3$ per loaf.

Results

The favorable harvest season of 1932 can be readily appreciated by looking at Table V where it will be seen that during the period of the experiment, from August 25th to September 12th, only 0.17 inches of rain was recorded at Edmonton. The 0.13 inches of this total, received on September 8th, was only sufficient to delay farmers who were stook threshing, in the forenoon, threshing machines being in operation everywhere in the afternoon. It had no appreciable effect on the barge stacks at all apart from wetting the top of the stack slightly.

As a result of these favorable conditions the moisture content of the grain in both experimental fields was low before harvesting started. After cutting, the weather continued dry and warm with the result that all samples dried quite rapidly, as will be seen by referring to Table V. The rate of drying was most rapid in the swathed grain and slowest in the barge stacks, and the grain was dry in all cases when threshed.

In planning this experiment it was intended to thresh the grain from each method at the same moisture content and then make comparative studies of each lot in storage, but it was impossible to do this with the amount of time and equipment available and as a result there was some difference in the moisture content of the grain harvested by various methods when it was threshed.

Table V

Moisture in standing and harvested grain, temperatures and humidity, 1932

Date	Moisture in grain as % of total weight				Atmospheric temperature	Relative humidity	Rainfall	Average barge stack temperature
	Standing	Swathed	Stooked	Barged				
Field 1.								
Aug. 25	25.9*	25.9*	25.1*	28.4*	--	--	nil	--
27	20.4	15.8	--	24.2	68	28	"	71
30	20.1	15.0	16.9	23.6	64	37	"	64
31	--	--	--	--	--	--	0.01	--
Sept. 1	17.8	13.2	15.4	16.3	76	33	0.02	79
2	--	--	--	--	--	--	0.01	--
5	11.0	10.9	13.0	15.9	79	33	nil	80
7	11.0	9.6	11.5	14.2	82	--	"	82
8	--	--	--	--	--	--	0.13	--
10	14.2	--	--	--	--	--	nil	--
12	--	11.7	12.8	13.3	75	31	"	--
Field 2.								
Sept. 5	23.6*	23.6*	24.1*	23.6*	79	33	nil	--
7	22.5	20.6	22.6	23.1	82	26	"	83
8	16.7	12.4	--	20.2	--	--	0.13	--
10	14.5	--	15.9	17.9	82	29	nil	81
12	--	12.9	12.8	13.8	--	--	"	--

* Average moisture content at cutting.

Temperature of barge stacks. - Owing to the very favorable weather conditions prevailing, and the good condition of the grain at the time it was barged, the grain dried down steadily from the time it was cut, Field No. 1 being down to 14.2% in 13 days after cutting and Field No. 2 being down to 13.8% 7 days after cutting. The difference in rate of drying between the two is accounted for by the fact that more of the grain from a depression was unavoidably included in Field No. 1, giving it a higher average moisture content at time of cutting.

Stack temperatures as recorded in Table V indicate that the temperature of the grain in the stacks never exceeded atmospheric temperatures by more than three degrees and most of the time temperatures were approximately the same. There was very little evidence of sweating or moulding in the stacks at any time and none of the stacks showed any evidence of sprouting or growing on the ground.

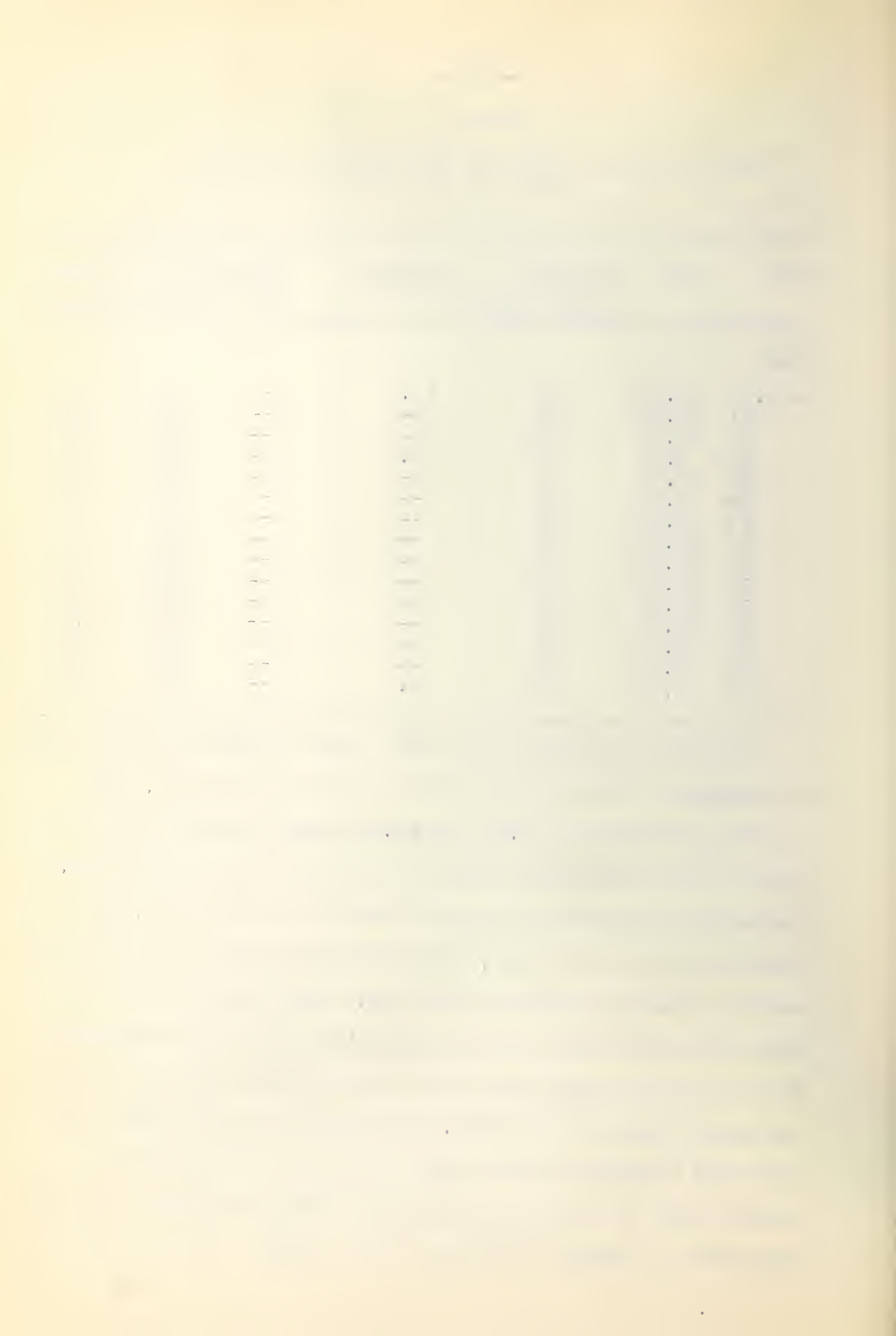
Temperature, moisture, stored combined wheat. - The straight combined grain was threshed between 9:30 A.M. and 8:00 P.M. on September 10th and placed in an ordinary grain bin at an average moisture content of 13.90%. Atmospheric temperature at 15:30 P.M. was 82° and most of the grain went into the bin at approximately this temperature. Temperature readings were taken twice daily for the first four days after threshing and then once a day for six more days and these figures are recorded in Table VI.

Table VI

Temperature and moisture of straight combined wheat in the bin

Date	Hour	Maximum atmospheric temperature	Average moisture	Temperature of wheat		
				Top	Centre	Bottom
1932						
Sept.10	21.50	82	13.9	--	80	79
11	10.50	63	--	--	83	76
11	20.00	63	--	--	83	79
12	8.00	66	14.5	--	82	83
12	21.00	66	--	--	83	74
13	8.00	78	--	--	81	79
13	21.30	78	--	--	81	71
14	14.00	63	--	--	82	75
14	19.30	63	--	--	81	77
15	21.00	62	--	--	82	74
16	21.05	62	--	--	81	72
17	22.00	68	--	--	80	74
20	11.00	51	--	--	81	70
21	18.00	58	--	--	78	65
24	8.30	61	--	--	78	66

The wheat appeared to be well into the sweat by the morning of September 12th, 36 hours after placing in the bin, when moisture readings of 14.53 and 14.45% were recorded for the grain at the middle and one foot from the bottom of the bin. The maximum temperature at the bottom of the bin (83°) was recorded at this time too, while the same temperature had been reached somewhat earlier at the top. The temperature of the grain decreased quite slowly especially when it is considered that the nights were quite cool, frost being recorded on one or two nights during the period. The amount of grain stored was about 450 bushels and this slow decrease in temperature is probably due to the slow diffusion of heat in bulked grain, as discussed by Swanson and Fenton (24) in their bulletin on



"The Quality of Wheat as Affected by Farm Storage."

Grade and weight per bushel. - A comparison of the grades and weights per bushel of all samples at time of threshing is shown in Table VII. This shows that the swathed grain had the lowest average moisture with a test of 11.73%, while the straight combined sample was highest with 14.16%.

As was to be expected under the harvesting conditions which prevailed, all of the samples graded high. The two barge samples and one binder sample graded one hard, and the rest one Northern. Although the swathed sample was graded one Northern with the rest it was not as strong a one Northern as the others because it had a lower weight per bushel and contained a few bran-frosted kernels. Variations in weights per bushel were fairly wide. The two barge samples were slightly heavier than the binder samples and both were heavier than the swathed and combined samples.

In the hot dry weather the swathed grain in Field No. 1 seemed to shrink and dry out more than the grain harvested by other methods and at one time had a moisture content as low as 9.56%. It will be remembered that the stand was somewhat thin on this field, consequently a large proportion of the heads were directly exposed to the sun and wind. In Field No. 2 the swath was much heavier and a smaller percentage of heads were directly exposed to the sun with the result that shrinkage was not so marked.

Table VII

Moisture, grade and weight per bushel of grain, 1932

Method of harvesting	Date of threshing	Average moisture at threshing %	Grade	Weight per bushel lb.
Field 1.				
Binder	Sept. 12	12.4	1°	65.0
Swather	Sept. 12	11.7	1°	60.5
Combine	Sept. 10	14.2	1°	62.0
Barge	Sept. 12	13.3	1 Hard	65.5
Field 2.				
Binder	Sept. 12	12.7	1 Hard	65.0
Swather	Sept. 12	12.9	1°	64.5
Combine	Sept. 10	13.9	1°	64.0
Barge	Sept. 12	13.8	1 Hard	66.0

Protein, milling and baking. - The protein results which are shown in Table VIII indicate that the fields harvested by various methods were not as uniform in protein content of grain as was desirable. Whether this lack of uniformity is due to getting samples from low and high parts of the field or whether it is due to experimental error, is difficult to say. Ordinarily there is no reason for believing that the total nitrogen content of stooked grain should be lower than that of swathed or combined samples from the same field. The milling yields also shown in Table VIII show an advantage in favor of the swathed sample from Field No. 2 which was on summerfallow although a general conclusion cannot be based on the result of one test. All of the yields obtained were high and with the exception of the swathed sample, fairly uniform.

The baking results shown in Table IX indicate that the samples harvested by the binder and thresher were somewhat poorer than the others, and this difference may be due to the lower protein content of those samples. The protein level of these samples is in the range where small increments make themselves felt most markedly, and a variation between 12.4% and 13.6% must be considered of importance in its effect on baking quality. As the difference in protein content may be due to an error in sampling, the differences in baking quality cannot be considered significant as related to the method of harvesting.

Discussion. - As was to be expected under the favorable conditions of crop and weather which prevailed in the harvest

Table VIII

Milling data on 1932
methods of harvesting samples

Sample No.	Description	Weight per bushel	Grade	Protein % (13.5% H_2O)	Milling data	
					Straight flour	Total flour
121	Swath and combine	64.5	1°	14.4	75.4	80.3
122	Swath and combine	60.5	1°	13.6	73.6	78.3
123	Straight combine	64	1°	14.2	73.2	80.3
124	Straight combine	62	1°	13.6	72.6	78.1
125	Binder and thresher	65	1 Hard	12.8	72.4	78.0
126	Binder and thresher	65	1°	12.4	72.6	78.0
131	Header barge	66	1 Hard	13.1	72.3	76.8

Table IX

Baking data on same samples

Sample No.	Absorption	Loaf volume	Basic formula					Loaf volume	Bromate formula				
			Appearance		Crumb		Partial baking score		Appearance		Crumb		Partial baking score
			Color	Form	Color	Texture			Color	Form	Color	Texture	
121	69	720	5	5	7.5g	8	58	749	5	4s	8	7.5-o	57
122	68	684	5	4.5s	8	8	58	670	5	5	7.5g	8	59
123	69	670	5	4.5s	8.5	8	60	724	5	4.5s	8	7.5-o	57
124	67	692	5	4.5s	8.5	8	58	672	4.5d	4s	8	7-o	53
125	68	618	5	4s	8	8	57	593	5	4.5s	7.5g	8	57
126	67	598	5	4s	7.5g	7.5c	54	621	5	4s	7.5g	8	55
131	70	650	5	4s	8	7.5c	58	665	4.5d	4.5s	7.5g	8	58

season of 1932, the results as measured by commercial grades and moisture content of grain were eminently satisfactory under all methods of harvesting. The results indicated that under conditions such as prevailed in the Edmonton district in that year the header barge is a satisfactory method of harvesting and capable of producing a grade of grain equal to or superior to the other methods. However, in view of the fact that conditions were more favorable than normal it would not be wise to base general conclusions on the results of this experiment which would be expected to apply year by year.

The fact that the swathed grain in Field No. 1 had a lower weight per bushel and a slightly inferior strength of grade to the grain harvested by other methods is one which is often associated with the method. So much of the grain is exposed to the effect of hot sun, drying winds, and a constant wetting and drying by dews, frosts and rain that it is only natural that it should reflect prevailing weather conditions more than other samples. In a thin crop such as in Field No. 1 it is quite obvious that the degree of shrinkage is quite severe. In a heavier stand, such as in Field No. 2, shrinkage was not a serious factor but, due to exposure to frosts after cutting, a larger proportion of bran-frosted kernels were included in this sample than in the others, and this is one of the well-known hazards of the method.

Straight combining yielded a sample of grain that from the standpoint of commercial value as determined by grade, was equal to those harvested by other methods and it might be concluded that when and where similar conditions prevail this is a satisfactory method of harvesting in northern

Alberta.

In the comparison of milling and baking data on the various methods the binder samples appear to be poorer than the others. This is probably due to the difference in protein content. Apart from these two samples the differences between the other samples were not large enough to be regarded as significant.

Conclusions

While it is unwise to base definite conclusions on the result of one year's work it would appear reasonable to assume that under favorable harvest weather such as prevailed in the Edmonton district in 1932, well-matured and uniformly ripe wheat barged at an average moisture content of 25.9% or less will yield a quality of grain that, from the standpoint of commercial grade and milling and baking value, is equal to or better than similar wheat harvested by other methods.

Comparison of Harvesting Methods and Their Effect on Quality of Wheat, 1933.

Introduction

After making arrangements with Mr. Gillies of Clover Bar to continue the methods of harvesting experiments during the season of 1933, the author was sent to Europe and it became necessary to make arrangements for someone else to carry on the work. Accordingly, the 1933 experiments were turned over to Mr. A. T. Sinclair and Dr. A. G. McCalla who carried out the work as previously arranged and compiled the results. Profiting by the experience of the previous year it was possible to improve on the technique and to get an even more complete picture of the situation than was possible in 1932.

The field of wheat used for the 1933 study was a different portion of the same field that was used in 1931 and 1932. The portion of the field selected for the study however, was not as uniform as desirable, being somewhat rolling, and in order to get sufficient acreage to cover the study it was necessary to use two different sections in the field. These sections were designated Field No. 1 and Field No. 2. Field No. 1 consisted of about 13 acres of fairly uniform Marquis Wheat grown on stubble land. Field No. 2,a field of four acres of the same variety grown on fallow. The wheat was harvested by the same four methods as used in 1932, namely, binder and thresher, header barge, swather and combine, and straight combine. The grain was cut at two stages of maturity as measured by moisture content, the first at approximately 40% and the second at 30%. The grain was threshed

at as close to 15% moisture as it was possible to do so.

Mr. Clyde Gillies supplied the binder and header barge as before, the International Harvester Co. kindly loaned a swather and combine, and a tractor to operate the latter was supplied by Mr. Allan Gillies.

Methods

The four methods of harvesting were used on Field No. 1. The first three acres were cut around the field using the binder, the second using the header barge and the third using the swather. The cutting was done on August 22 with the binder, when the average moisture content of the kernels was 31%, and on August 23 with the barge and swather. The moisture range for the field was from 15% to 53%, but these figures are extreme because of the variations in the field. The extremes represent the conditions of small spots only, the ripening in this field being fairly uniform. The straw was short and dry, there were few green spots, and the yield of grain was about 30 bushels per acre. When the grain left standing reached a moisture content of 15% combining was started, but due to an accident with the machinery the bulk of the combining was not completed until the following day.

Three methods were used to harvest the grain in Field No. 2, the straight combine not being used. The field was cut in a manner similar to that used in the first field except that only one-half acre lots were cut with the binder and swather, and the remaining three acres with the header barge. On August 22 the average moisture content of this field was 42% and on this date cutting with the binder and swather was completed. There was a slight rain that

night and barging was not started until the afternoon of August 23 and not completed until the morning of August 24. At this time the average moisture content had fallen to 39%. It is to be noted, therefore, that any advantage of maturity was in favor of the barge-cut grain. The moisture range of this field was from 24% to 51%. The straw was much heavier than, and not as dry as that in the first field. The stand of grain was not as uniform, but yielded about 35 bushels per acre.

After the grain was threshed, the combined, swathed, and header barged samples from field 1 and the barged samples from field 2 were stored in four sections of a large bin. The small bins were 8 ft. 4 in. x 4 ft. 4 in. in size, each being separated from those adjoining by a two inch air space. The grain stored was sufficient to make a depth of approximately 4 ft. 6 in.

Moisture and temperature determinations. - All moisture determinations of standing and cut grain were made in the same way. Approximately 80 heads were chosen at different places in the field in the case of standing grain, and from different stooks, swaths or stacks in the case of cut grain. These were taken to the laboratory in air-tight cans, threshed out immediately, dried at 100°C. for 5 hours, ground, and dried again at 130°C. for one hour. In sampling the barge stacks for moisture determination, heads were taken from three places in the stack, a foot from the top, at the centre, and a foot from the bottom. Only heads from the inner parts of the stacks were taken. Samples of binned grain were taken for moisture determination by sampling from several different places in the bin.

The temperatures of barge stacks were determined daily for 18 days from the time of harvesting. Maximum thermometers were inserted near the middle of the stacks, one foot from the top, at the

centre, and one foot from the bottom. In the previous year these thermometers were read one and one-half hours after insertion, but this year they were allowed to remain in the stack for 24 hours. The reading recorded is, therefore, the maximum temperature for the period.

The temperatures of the grain in the bins were determined with maximum thermometers placed in the middle of the bins, six inches from the top, at the centre and six inches from the bottom of the grain. These thermometers were left in the bins, being removed only to take the readings and to lower the mercury columns.

Grading, protein determinations and baking tests were carried out as in the previous year.

Results

The period covered in this study was from August 26 to September 13 and during this time the weather was quite showery including one general rain of 0.66 inches on August 31 and showers on September 5, 6, 10 and 11, or a total for the period of 0.91 inches. Samples were collected every other day during this period and the moisture contents of the standing and harvested grain are given in Table X. The grain in the barge stacks dried more slowly than the standing grain or that in swaths or stooks, and was less affected by the rain. This was particularly noticeable following the rain of August 31, when the moisture content of the grain in the barge stacks in field 1 was unaltered, while that of the grain in the swaths and stooks increased markedly. It must be noted that the method of sampling was not as accurate as desirable, and in sampling barge stacks and stooks, the method was more subject to error than in sampling the swaths or standing grain. This could not be overcome since in stooks and stacks different heads were

Table X

Rates of drying of standing and harvested wheat.

Date	Moisture in grain as % of total weight				Atmospheric temperature	Average relative humidity
	Standing	Swathed	Stooked	Barged		
Field 1.						
Aug.26	22.1	19.3	25.6	25.3	78	54
28	16.4	16.1	19.8	28.7	89	52
30	23.9	16.4	13.9	25.8	58	74
Sept.1	23.3	23.5	25.8	25.7	57	58
3	21.3	19.4	20.5	20.7	66	58
5	20.2	21.2	19.5	20.9	40	81
7	23.8	24.2	20.9	19.9	56	68
9	18.1	17.9	17.9	21.5	83	56
11	17.6	20.8	15.7	22.7	67	46
13	14.6	16.5	14.6	17.9	73	58
Field 2.						
Aug.26		31.7	34.5	27.8	78	54
28		16.8	23.7	31.2	89	52
30		15.5	22.0	25.5	58	74
Sept.1		22.3	24.1	27.8	57	58
3		30.0	24.3	29.5	66	58
5		20.8	20.0	31.8	40	81
7		23.3	21.2	27.7	56	68
9		19.3	16.9	25.5	83	56
11		20.8	15.9	22.1	67	46
13		15.4	14.6	22.3	73	58

Average moisture content at cutting

Field 1 31%

Field 2 42%

subject to large differences in conditions. Another consequence of the differences in conditions under which the aging of the various samples took place was the greater effects of weathering noticeable in the swathed and standing samples. All heads in these lots were weathered, whereas only the outer heads of stooks and stacks were so affected.

Temperature and moisture studies of barge stacks. - A detailed study of the drying of barge stacks was made, and the results of temperature and moisture determinations are recorded in Table XI. These results show that the drying of the stacks in Field 1 was fairly regular, and that rain had but little influence on the moisture content. The stacks in Field 2 dried very slowly, probably as a result of comparatively low temperatures and fairly high humidities during the period the grain was in the stacks. It is obvious that the slow drying could not have been due to lack of air circulation because the stack temperatures were largely influenced by the atmospheric temperature. There seems to have been little or no heating in the stacks in either field, and only a few cases of localized heating were noted in areas where the straw was green or where there were weeds. The amount of grain affected by these spots was very small. Most of the stacks in Field 1 were moulded to some extent, and those in Field 2 were much worse. Sprouting of the grain took place in a layer 2 to 6 inches deep at the bottom of many stacks, especially in Field 2, where some of the grain had to be discarded because it could not be threshed. Sprouted grain was found near the top of the stacks where rain had penetrated and also in occasional spots throughout some of the stacks.

Table XI

Temperature of barge stacks.

Date	Hour	Moisture	Maximum atmospheric temperature	Rainfall	Average relative humidity	Temperature of stacks Top	Centre	Bottom
			°F.	in.		°F.	°F.	°F.
Field 1.								
Aug.24	11.45	35.2	68	nil	58	71	71	71
25	11.20	36.7	75	"	54	62.5	62	62
26	10.50	25.3	78	"	54	71	71	71
27	10.35	25.8	80	"	40	61	61	61
28	10.35	28.7	89	"	52	61	61	61
30	16.30	25.8	58	"	77	80	70	70
31	11.40	22.1	56	0.66	84	60	59	58
Sept.1	11.20	25.7	57	nil	58	57	57	57
2	11.50	21.2	60	"	57	51	50	50
3	11.50	20.7	66	"	58	47	49	50
4	12.30	23.1	58	"	64	57	52	49
5	11.00	20.8	40	0.07	81	50	49	48
6	11.30	20.4	43	0.09	43	40	41	43
7	11.20	19.9	56	nil	68	44	44	44
8	12.00	24.5	79	"	62	60	60	58
9	11.20	21.5	83	"	56	68	64	58
10	12.20	19.1	65	0.05	60	65	66	63
11	11.25	22.7	67	0.04	46	59	58	57
Field 2.								
Aug.24	11.30	38.7	68	nil	58	71	71	71
25	10.20	36.7	75	"	54	62	62	62
26	10.30	27.8	78	"	54	67	66	66
27	10.20	33.4	80	"	40	62	61	61
28	10.20	31.2	89	"	52	61	61	61
30	11.30	25.5	58	"	74	71	70	63
31	10.20	26.8	56	0.66	84	59	58	56
Sept.1	11.00	27.8	57	nil	58	56	57	57
2	11.05	28.2	60	"	57	52	49	50
3	11.30	29.5	66	"	58	49	50	50
4	12.00	25.9	58	"	64	50	48	48
5	10.40	31.8	40	0.07	81	49	51	49
6	11.20	25.2	43	0.09	43	41	41	45
7	10.50	27.6	56	nil	68	44	44	50
8	11.30	23.4	79	"	62	50	48	50
9	11.10	25.5	83	"	56	65	64	63
10	12.00	23.7	65	0.05	60	60	63	63
11	11.00	22.1	67	0.04	46	59	59	58

Moisture content, grades and weights per bushel. - The average moisture contents, grades and weights per bushel of all samples at the time of threshing are presented in Table XII. The stook (binder and thresher) swath and combine and straight combine samples were all threshed on September 13 and 14, but the header barge samples were left until later. Eventually the barged grain had to be threshed at a higher moisture content than the other samples because they dried very slowly during the latter part of the time they were left in the stacks. The moulding and sprouting in some of the stacks were becoming progressively worse, and it was felt that nothing could be gained by leaving them any longer, especially as the weather was unsettled.

The stook sample from Field 1 graded a good 1 Northern, while that from Field 2 graded a poor 1 Northern owing to immature kernels resulting from early cutting. These two samples also had the highest weight per bushel. The swath and combine and straight combine samples from Field 1 both graded a poor 1 Northern owing to bleaching. The straight combine sample was slightly heavier per bushel. The 2 Northern grade given the swath and combine sample from Field 2 was probably unjustified except for the cracked kernels caused by faulty adjustment of the thresher. The barged grain from Field 1 graded 4 tough and that from Field 2, 5 tough. The weights per bushel were also lower than those of grain harvested by other methods. The samples were dark in color, musty, and contained sprouted kernels, the grain from Field 2 being worse than that from Field 1 in these respects.

It has already been noted that the straight combine, swath and combine and header barge samples from Field 1 and the header

Table XII

Moisture, grade and weight per bushel of grain harvested by different methods.

Method of harvesting	Date threshed	Average moisture at threshing	Grade	Weight per bushel
		%		lb.
Field 1.				
Binder and thresher	Sept. 13	14.6	1° (good)	64.5
Swath and combine	" 14	13.8	1° (poor)	63.0
Straight combine	" 13	13.7	1° (poor)	64.0
Header barge	" 29	16.4	4 tough	60.5
Field 2.				
Binder and thresher	Sept. 13	14.6	1° (poor)	64.5
Swath and combine	" 14	14.0	*2°	63.0
Header barge	Oct. 3	16.7	5 tough	61.5

* 2° because of cracked kernels due to faulty adjustment of thresher.

barge sample from Field 2 were stored in small bins. Temperature and moisture determinations were made on the straight combined wheat for 11 days after threshing. The results are presented in Table XIII. There was a slight increase in moisture content during the first four days of storage, but the increases noted are barely significant. The temperature showed little if any tendency to increase, although the original temperature was maintained for several days in the centre of the bin. After this the grain cooled down very gradually. There was no indication of any localized heating. Temperatures were taken for a few days on the grain stored in the other bins, and gave essentially the same results. The rate of cooling of the wheat was very slow.

Milling and baking. - The milling and baking tests on the 1933 samples were carried out under the direction of Dr. McCalla and the results are presented in Tables XIV and XV. The study was somewhat more extended than with the 1932 series. Small samples were collected from each lot at the time of threshing in 1933. As indicated previously, the remainders of the swath and combine, straight combine, and two header barge samples were stored in bins on the farm of Mr. C. Gillies. These bins were sampled early in March, 1934, the grain being brought to the laboratory and used in milling and baking tests.

The samples collected at the time of threshing were graded at the time of collection, then stored in the laboratory until March, 1934. While the laboratory conditions under which the samples were stored were uniform, they were such that the samples dried relatively slowly. This probably played some part in determining the final quality of these samples, especially the barge samples which were tough when collected.

Table XIII

Temperature and moisture of straight combined wheat in the bin.

Date	Hour	Maximum atmospheric temperature	Average relative humidity	Average moisture	Temperature of wheat		
					Top	Centre	Bottom
		°F.	%	%	°F.	°F.	°F.
Sept.14	10.30	77	66	13.96	73	70	68
15	10.30	55	86	13.96	73	73	74
15	21.10	55	86	---	70	72	66
16	9.30	60	59	14.10	71	71	71
16	19.00	60	59	---	65	72	67
17	14.00	54	66	14.38	68	73	74
18	12.00	49	78	13.90	67	71	69
19	11.00	64	62	13.74	67	69	60
19	16.30	64	62	---	69	68	61
20	10.50	72	54	13.41	66	68	62
20	16.50	72	54	---	65	68	60
21	10.00	66	60	14.10	66	66	62
22	9.40	60	54	11.95?	64	66	57
23	14.45	50	55	14.04	62	65	52
24	16.00	41	55	13.99	59	58	58
25	17.00	39	72	14.15	57	60	53

Table XIV

Milling data on 1933 methods of harvesting samples, Edmonton

Method of harvesting	Field No.	Time of sampling	Grade at time of milling	Protein % (13.5% H_2O)	Milling data	
					Straight flour	Total flour
Binder and thresher	1	At threshing	1°	14.7	66.2	72.6
Swath and combine	1	"	1°(poor)	14.7	69.5	74.2
Straight combine	1	"	2°	15.3	67.4	72.4
Header barge	1	"	3°	14.7	70.3	75.9
Binder and thresher	2	"	1°	15.2	69.0	73.8
Swath and combine	2	"	1°(poor)	15.1	68.7	74.4
Header barge	2	"	4°	15.2	69.0	73.7
Swath and combine	1	After bin storage *	1°(poor)	15.0	68.7	73.4
Straight combine	1	"	1°	15.2	68.6	73.4
Header barge	1	"	2°	15.0	70.0	75.2
Header barge	2	"	4°	15.3	70.0	74.6

* Samples stored in bins at Mr. Gillies' farm from time of cutting until March, 1934.

Table XV

Baking data on 1933 methods of harvesting samples, Edmonton

Method of harvesting	Field No.	Time of sampling	Absorption	Loaf volume	Appearance Crumb Color	Appearance Crumb Form	Crumb Color	Crumb Texture	Partial baking score
Basic formula.									
Binder and thresher	1	At threshing	64	711	5	4s	7.5	7.5	50
Swath and combine	1	"	64	648	4.5d	4s	6.5	7-o	46
Straight combine	1	"	66	612	4p	3s	7	7-o	48
Header barge	1	"	66	691	5	5	5g	5.5co	42
Binder and thresher	2	"	64	682	5	4s	7	7c	48
Swath and combine	2	"	64	731	5	3.5s	7.5	7-o	48
Header barge	2	"	63	628	5	4f	5.5g	5.5co	39
Swath and combine	1	After bin storage*	64	706	4.5p	4s	7.5	7-o	48
Straight combine	1	"	64	580	5	3.5s	7.5	7-o	48
Header barge	1	"	64	670	4d	5	7	7.5	49
Header barge	2	"	64	735	4d	5	6.5	7-o	47

Table XV (Continued)

Method of harvesting	Field No.	Time of sampling	Absorption	Loaf volume	Appearance		Crumb		Partial baking score
					Color	Form	Color	Texture	
Bromate formula.									
Binder and thresher	1	At threshing	64	698	5	4s	7.5	7.5	50
Swath and combine	1	"	64	576	5	3.5fs	5.5g	5.5co	40
Straight combine	1	"	66	532	4p	3.5fs	6.5g	6.5co	46
Header barge	1	"	66	530	4.5d	4f	4g	4.5co	36
Binder and thresher	2	"	64	774	4.5d	4s	7.5	7.5	50
Swath and combine	2	"	64	618	4.5p	4s	6.5g	7-c	46
Header barge	2	"	63	579	5	4.5f	5g	5.5co	39
Swath and combine	1	After bin storage *	64	624	4.5d	4.5s	7g	8	51
Straight combine	1	"	64	606	4.5p	3.5fs	6.5g	7c	46
Header barge	1	"	64	640	4d	5	6.5g	7-c	47
Header barge	2	"	64	707	4d	5	7.5	7.5	50

Table XV (Continued)

Method of harvesting	Field No.	Time of sampling	Absorption	Loaf volume	Appearance		Crumb		Partial baking score
					Color	Form	Color	Texture	
Malt-bromate-phosphate formula (0.3% of 200° lintner malt, 0.001% bromate)									
Binder and thresher	1	At threshing	64	752	4d	4.5s	6.5g	7-o	46
Swath and combine	1	"	64	608	4d	5	5g	5.5co	39
Straight combine	1	"	66	583	4d	2.5s	5.5g	6.5co	43
Header barge	1	"	66	560	4d	4f	4g	4.5co	35
Binder and thresher	2	"	64	844	4d	5	7.5	7-o	49
Swath and combine	2	"	64	638	4d	5	6g	6co	43
Header barge	2	"	63	567	4.5d	4f	4.5g	5co	35
Swath and combine	1	After bin storage*	64	697	4d	5	6g	6co	43
Straight combine	1	"	64	600	4d	3s	5.5g	6.5co	41
Header barge	1	"	64	694	4d	4fs	5.5g	6co	41
Header barge	2	"	64	762	4d	5	6.5g	6.5co	45

* Samples stored in bins at Mr. Gillies' farm from time of cutting until March, 1934.

Discussion

The weather conditions under which these tests were made were much more unfavorable for harvesting than were those of 1932. In that year only 0.17 inches of rain fell during the time that the barge stacks were exposed. In 1933, up to September 13 and 14, when all samples except those harvested with the barge were threshed, there was 0.91 inches of rain. At this time the grain in the stacks had dried insufficiently to make threshing possible, and during the two weeks which followed, an additional 1.63 inches of rain fell. Thus the barge stacks were subjected to a total rainfall of 2.54 inches, and in this respect the tests were unfair to this method of harvesting. It must be emphasized, however, that since the reason for delayed threshing was the slow rate of drying it is this factor which was responsible for the extra exposure to weathering. The comparatively high moisture content of the grain at time of cutting undoubtedly was also a big factor in the subsequent deterioration in quality during the severe weather conditions which followed. Added to this was the further difficulty that barge stacks were placed on slightly damp ground and temperature and humidity conditions were generally unfavorable to rapid drying. The difficulty of building good stacks with the available equipment has been mentioned previously, and although reasonable care was exercised in building and topping the stacks, a few took water in spots during the heavy rains, and this had the effect of accentuating the other unfavorable conditions.

The unfavorable results obtained with the header barge in 1933 must be attributed to the combined effect of damp ground, high moisture content and poor drying conditions. It can be said

definitely that the immediate cause of deterioration was not heating, but was due to what Coleman and Rothgeb (9) describe as moulding and stack-staining, the latter type of injury having a very deleterious effect on baking properties.

As already noted, sprouting of grain in the bottom of the stacks was rather general. There was a light rain on the morning of the day the barging was started, but it was scarcely sufficient to make the surface of the ground moist. The sprouting was the worst in Field 2 where the straw was greener, and must have been caused by a combination of soil moisture, green straw and unfavorable atmospheric conditions.

The stook (binder and thresher) sample from Field 1 was the best of all those collected. It would appear that under such conditions as obtained in the fall of 1933 this method of harvesting must be considered the most satisfactory. A moisture content of 30% at cutting appears slightly better than one of 40%, but the cut in grade which resulted from the inclusion of immature kernels was slight. This is also true of the effect of weathering on swath and combine and straight combine samples.

Temperature, moisture content stored combined grain. - The temperatures of stored combined grain are not considered serious because these at no time increased to above the atmospheric temperature at the time the grain was put in the bin. After the first few days the temperature fell gradually, the rate of decrease probably being largely determined by the rate of diffusion of heat, (Swanson and Fenton (24). A close examination of the 1932 results shows that a similar condition obtained, and it

is believed that the slower rate of cooling was due to the larger mass of grain stored in the bin. The increase in moisture content of the samples both in 1932 and 1933 was probably significant, but it is believed was not at all serious.

Changes in storage, protein, milling and baking. - All samples were graded at the time they were milled. The binder and thresher, swath and combine and straight combine samples were essentially the same as in the fall of 1933, although one 1 Northern (poor) sample was dropped to 2 Northern, and the sample which graded 2 Northern because of cracked kernels was raised to 1 Northern (poor). The barge samples had each improved a grade and were, of course, no longer tough. These changes took place under the conditions of laboratory storage. Under bin storage conditions there was even a greater change in one of the barge samples which improved two grades from 4° to 2°. The other barge sample improved one grade. The straight combine sample was graded a straight 1 Northern after bin storage.

The protein results are more uniform than those obtained with 1932 samples. There were apparent small increases in protein content during bin storage of two of the samples, but these were probably the result of sampling errors, or possibly of slight losses of carbohydrates in respiration during storage.

The milling yields were all lower than those obtained with the 1932 samples. There was an indication that the header barge samples gave slightly higher yields than the other methods, but the differences were hardly significant. One of the binder and thresher samples was low in yield of straight flour, but

somewhat high in red dog. Probably the differences obtained should not be considered particularly significant in such a short series.

The samples were all baked by three formulae and the results are presented in Table XV. The only distinct features brought out by the use of the basic formula were the lower loaf volumes of the straight combine grain sampled both at cutting and after storage, and the poorer crumb color and texture of the header barge lots sampled at the time of threshing. The low loaf volumes of straight combine samples occurred under the conditions of all three formulae and appear to be an inherent characteristic of the material. The poor crumb scores of the barge samples did not occur with the material stored in the bins before milling, so probably the slow drying under the higher temperatures of the laboratory caused a certain amount of degradation in these samples.

The results of the bromate bake indicate that the binder and thresher samples were the best of all the material sampled at the time of threshing, but that the samples harvested by the other methods and bin stored were equal, or only slightly inferior, to the original binder and thresher samples. None of the binder and thresher wheat was bin stored, so comparisons of storage effects on these samples could not be made.

The results of the malt-bromate-phosphate bake indicate that the binder and thresher samples were superior both in loaf volume and partial baking score to those harvested by other methods, whether sampled at the time of threshing or after storage. As was to be expected from the quality of the barge

samples the poorest results were obtained with those samples taken at the time of cutting and stored in the laboratory. Storage in bins improved these samples quite markedly. It also improved the swath and combine sample to some extent, but not the straight combine sample.

Taken as a whole, these results show that the binder and thresher samples were somewhat superior to those harvested by other methods. The header barge lots were tough when sampled at the time of threshing, and the results indicate that these samples made the poorest bread. The loaf volumes of the straight combine samples were consistently lower than those of the binder and thresher or swath and combine samples, and the scores consistently lower than those of the binder and thresher samples. Bin storage improved the header barge samples most markedly, although some of the differences noted between the bin and laboratory stored samples may be attributed to the deleterious effects of the higher laboratory temperatures on the latter, as they dried slowly. Bin storage improved the swath and combine sample somewhat, but the straight combine sample little, if any.

Conclusions

The conclusions drawn from the 1933 results have been clearly indicated in the preceding section. Obtained under markedly different weather conditions than existed in 1932, the results, as far as the header barge is concerned, are the opposite to those of that year; therefore, it must be concluded that under unfavorable harvest conditions, such as prevailed in 1933, and with the type of equipment used, the header barge is

not a satisfactory method for harvesting wheat in the Edmonton district.

General summary of two years' work. - Two years of detailed studies of wheat harvested by the binder, barge, swather and straight combine methods gave almost directly opposite results in the Edmonton district. In 1932, under almost ideal harvest conditions, the barge method proved to be equal or better than the binder, swather or combine methods in producing samples of high grade and quality. In 1933, under adverse weather conditions, the barge samples were the poorest of those harvested by the four methods. Grades were low, and there was some loss of material due to moulding and sprouting in the barge stacks. Quality as determined by baking tests was lower for the barge than for the binder samples and although bin storage improved the grade and quality of the barge samples remarkably it was not sufficient to make them of equal grade.

In spite of the results obtained in the studies in the Edmonton district, however, it must be pointed out that in the drier areas of the Province in the brown soil wheat belt, the header barge method of harvesting has continued to increase up to and including the harvest season of 1934. Under the latter conditions, however, it must be pointed out that the normal harvest season more nearly approaches that which prevailed in the Edmonton district in 1932. The straw is riper, the daily temperatures higher, the humidity lower, and drying winds more prevalent than in the Edmonton district, and in practically all cases a much superior type of equipment is used.

It would appear that under Edmonton conditions in any season, but particularly in an unfavorable season, barging grain at 40 and even 30% moisture is not sound practice. If the barge is to be used at all under Edmonton conditions the moisture content of the standing crop should not exceed 25%.

A Comparison of Various Harvesting Methods in Respect to Moisture and Grade of the Grain.

Introduction

During the harvest seasons of 1929-30 and 31 statements were frequently made by grain companies, elevator operators and farmers that straight combined wheat was more likely to go out of condition in storage than wheat threshed from the stook. In the fall of 1931 the Northwest Grain Dealers Association and the Searle Grain Company of Winnipeg made a specific request to the Grain Research Committee of the National Research Council asking that they undertake an investigation into this problem. The reasons assigned for grain harvested by the combine going out of condition more readily than that harvested by other methods are (1) the tendency of operators to cut grain containing too much moisture; (2) the presence of green weed seeds and stems; (3) the presence of green kernels in the grain from fields that have matured unevenly; (4) the failure of the grain to undergo the so-called sweating process before it goes into the bin.

General experience has shown that many combine operators, particularly those of little experience do have a tendency to start combining before the grain is dry enough. The interval of from 5 to 21 days after binder harvesting has started during which their standing crop is exposed to possible damage by hail, wind, frost and snow is rather trying to many operators with the result that their impatience often outweighs their judgment and they start cutting. Coupled with this natural desire to get the grain harvested is the further fact that many operators' judgment of what constitutes dry wheat is not sound and this is further aggravated

by the fact that the combine will handle wheat considerably above 14% moisture quite well.

It is generally agreed that unless land is farmed specifically for the combine the problem of green kernels and uneven ripening is likely to be a serious one in some seasons. In districts of rolling topography and those subject to wind or insect damage in the spring, uneven ripening is bound to occur. Furthermore, the earlier combining is started in the season the more difficulty is likely to be experienced from green kernels and green weeds. This is particularly true around the borders of fields where insects and gophers have caused damage.

Many farmers do not appreciate the seriousness of the presence of large quantities of green weeds such as Russian thistle, Russian pigweed and lambs quarter which on many occasions contain 50 and 60% moisture at time of cutting. These, when mixed with the grain become a source of heating if the grain is near the border line of 14.5% moisture. When harvested by other methods these weeds dry out rapidly in the swath, stook or stack and do not present a storage hazard.

The question of sweating in grain is one that very little is known about. Most investigators are agreed that it is one manifestation of the after-ripening process and that it involves colloidal changes. Although little is known about the process itself its outward manifestation is recognized by all as a tendency toward an increase in moisture on the outer surface of grain. The general opinion of farmers and grain men is that all grain must go through this process and that in the case of combined grain it must do so in the bin and that this increases the storage hazard in grain of high moisture content cut by the combine.

The only way in which definite information could be obtained on these questions was by an extended survey of harvesting methods. Accordingly the Grain Research Committee undertook this task in the three prairie provinces in the harvest season of 1932 and the results as reported by Larmour, Geddes, and Cameron (16) did throw some new light on the subject. The Alberta survey was carried out by the writer and the details of the experiment as well as the results obtained will be discussed in the succeeding sections.

In passing, it might be well to mention that beginning with 1929 combines, and swathers and combines, were sold rather indiscriminately in Alberta, from Edmonton, south and east to the Montana and Saskatchewan borders, without much regard to the adaptability of these machines to particular districts. Some were even sold in the Peace River country. The result of this policy is, that today, combines are tending to become more and more concentrated in localized areas where they are best adapted. In districts where they have been found to be unsuited, farmers have either let the companies take them back, or are letting them rust in fence corners, or have sold them. In many districts where there were 15 to 20 combines in 1930 and 31 there are only two or three today. The swather and combine is proving even more unsatisfactory, except in certain cases, than the straight combine, farmers claiming heavy losses through excessive sprouting, shrinkage, wind damage and bleaching.

The header barge system has been spreading slowly from the Acadia Valley south of Oyen, since 1924. From 1927 until 1930 the numbers of these outfits used did not increase very rapidly

because men who were interested in switching from stook threshing to the barge method tried the combine first. Many of these men today have gone back to the use of the barge and are using it in conjunction with the combine. Since 1930 the number of barges in use has increased rapidly and there was an increase of several hundred per cent in 1932, with a continued increase in the wheat belt in 1933 and 1934.

While most of the barges were used in the territory east of the Red Deer River previous to 1932, they have now become established in the Vulcan, Arrowwood, Nanton, Dalemead, Airdrie, Three Hills, Stettler, Donalda, and Lougheed districts. During the fall of 1932 in the south of the province the stacks withstood the most severe weather conditions in an amazingly satisfactory manner.

Methods

During the moisture and grade survey which was carried out in Alberta during the harvest season of 1932, samples were gathered from combines and stationary threshers in the field and from trucks and country elevators. In every case an attempt was made to get comparable samples representing the various methods of harvesting. This was not always possible due in the early part of the season to the fact that straight combining was being carried out before grain was being stook threshed, and barge stacks were being held over until all of the crop was harvested. All samples were placed in air-tight, numbered containers, and boxes of samples were mailed to the laboratory daily. At the time of sampling the name and address of the grower, elevator, variety of grain, method of harvesting, temperature, relative humidity, and

elevator grade were recorded. On arrival at the University the moisture content of each sample was determined on a portion of the sample by running in the electric oven at 130°C. for one hour, and the remainder of the sample submitted to the Dominion Grain Inspection office at Edmonton for the official grade.

During the last week of July and the first two weeks of August a wave of extremely hot weather was experienced in the southern and southeastern portions of the province. This had the effect in many districts of ripening the grain too rapidly with the consequence that in those areas a lot of the grain had a test weight somewhat lower than ordinary.

The first sample of grain was taken from a combine at Barons on August 18th, this being the only machine straight combining in the district at that time. On August 19th, sampling was started at Warner within 15 miles of the Montana border. This is usually the first district in the province to start harvesting operations and was selected as the starting point for that reason. At this date straight combining was general in the district. No swathing is done in this district and only a small percentage of the grain is cut with the binder, none of which was threshed at that time. Daily temperatures at this time were running up to 85 and 90°F. and it was interesting to note that many truck loads of grain were coming from the combine with an initial temperature of 80°F. It was observed that the majority of the wheat was being taken in as straight grade by the elevator operators, and yet nearly all of the operators between Warner and Macleod were having trouble with certain bins of combined grain heating.

Gradually working northward from Warner, samples were gathered

at New Dayton, Stirling, Kipp, Coalhurst, Monarch and Macleod, between August 19th and 22nd. On August 21 and for the succeeding few days, rain was general throughout the whole of southern Alberta, so samples were taken from elevators, farm trucks and farm bins on August 22nd and 23rd in the Macleod, Nobleford, and Barons districts, and as all harvesting operations were at a standstill sampling was stopped and a return to Edmonton was made.

On September 1st, 10th and 12th, samples were obtained from straight combines and swathers and combines in the Clover Bar district near Edmonton, and on September 14th, sampling was started in the Irricana district. By this time threshing by all methods was in full swing and no difficulty was experienced in getting comparable samples although showery weather was making operations spasmodic in some districts. The Cayley, Nanton, Parkland and Claresholm districts were sampled on August 15th and 16th, and on the 17th the survey was carried eastward into a good combine area at Barons. From Barons the survey continued north through the Carmangay, Champion and Vulcan districts on the 18th and 19th. A heavy rain in the Vulcan area on the 18th and again on the 19th caused a cessation of harvesting activities for a week, so samples were taken in the elevators at Vulcan on the 20th, and a jump made from there to Oyen in the south-eastern section of the province.

From Delia near the Red Deer River, east to the Saskatchewan border a large amount of grain had been barged but at this time very few of the barge stacks were threshed. Sampling was carried on in the Oyen and Naco districts on September 22nd and 23rd, and at Cereal and Hanna on the 24th. Throughout all of this territory,

header barge stacks were to be seen everywhere, very few of them having been threshed. Many stacks were examined and in all cases the grain was in good condition in spite of being subjected to abnormally heavy rains for that territory. On the evening of September 24th, sleet and snow set in at Hanna and heavy rains covered the area between Hanna and Calgary. On September 26th samples were taken from elevators in the Beiseker and Three Hills districts and as harvesting operations were again tied up for a week or more it was decided to return to Edmonton.

It turned out that in the area between Lacombe and Vulcan, and the foothills on the west and the Red Deer River on the east, the fall of 1932 was one of the worst on record and as a result, between 35 and 50% of the grain remained in the field waiting to be straight combined, threshed with the combine and pick-up, or stook threshed the following spring.

Weather conditions throughout the whole period of the survey were extremely bad as a brief reference to Table XXIV will show, and for this reason it was impossible to get as large and representative number of samples as would have been the case had weather conditions been at all favorable. The last samples were gathered in the Three Hills - Beiseker area on September 26th, and at that time in the territory from Calgary north to Lacombe and east to the Red Deer River, less than 30% of the grain had been threshed - 20 to 25% more was threshed out of the snow during the winter, and the balance threshed in the spring of 1933. Had it been possible to renew the survey in that area about the end of November, some interesting results could have been obtained on the effect of adverse weather conditions on grades.

Results

The rainfall recorded at several Dominion Meteorological Stations during the period of the survey is recorded in Table XXIV. In this survey 190 samples of wheat were collected and these have been classified according to kind of wheat, method of harvesting and exposure to rainfall in Table XVI. Only five samples of winter wheat were obtained and as the numbers were so small they have been grouped in with the spring wheat samples in the grade analysis.

Owing to the fact that wet weather set in almost immediately after the survey started only 15.15% of the samples were obtained without exposure to rainfall. 13.15% were collected that had been exposed to only one rain, and 71.5% had been exposed to two or more rains.

Of the total number of samples 29.4% were stook-threshed, 13.6% swath and combined, 52.6% straight combined, and 4.2% header barged.

In Table XVI the samples collected are classified according to kind of wheat, method of harvesting and exposure to rainfall, while complete data for the samples collected before rain, after one rain, and after two or more rains, is shown in Tables XVII, XVIII and XIX. Field and elevator samples are tabulated together. The data shown in Tables XVII, XVIII and XIX has been re-classified according to method of harvesting, moisture content and grade, and these classifications are shown in Tables XX, XXI and XXII, which also segregate the samples into those harvested before rain, after one rain, and after two or more rains, respectively.

In order to obtain a figure for the average grade which would

Table XVI

Moisture and Grade Survey.

Classification of samples according to kind of grain, method of harvesting & exposure to rainfall.

Harvesting method	Before Rain		After 1 Rain		After 2 or more Rains		Total	
	No.	%	No.	%	No.	%	No.	%
Stook Threshed								
Common Wheat	3	1.5	2	1.05	51	26.8	56	29.4
Winter Wheat	-	-	-	-	-	-	-	-
Tot. Stook Threshed	3	1.5	2	1.05	51	26.8	56	29.4
Swathed & Combined								
Common Wheat	-	-	2	1.05	24	12.6	26	13.6
Winter Wheat	-	-	-	-	-	-	-	-
Total Swathed and Combined	-	-	2	1.05	24	12.6	26	13.6
Straight Combined								
Common Wheat	21	11.05	21	11.05	53	27.9	95	50.0
Winter Wheat	5	2.6	-	-	-	-	5	2.6
Tot. Straight Combined	26	13.65	21	11.05	53	27.9	100	52.6
Header Barge								
Common Wheat	-	-	-	-	8	4.2	8	4.2
Winter Wheat	-	-	-	-	-	-	-	-
Total Header Barge	-	-	-	-	8	4.2	8	4.2
Total All Methods	29	15.15	25	13.15	136	71.5	190	100

Table XVII

Moisture and grade of grain harvested in Alberta before rain by different methods

Samples collected from farmers' fields and elevators at threshing time.

(S.C.= swathed & combined; S.T.= stook threshed; S.= straight combined; H.B.= header barge)

Lab. No.	Place	Date	Time	Temp. °F.	Rel. Hum.	Variety	Harvesting Method	% Moisture	Grade	
		Aug.								
2	Barons	18	3 p.m.	86	35	Marq.	S.	13.92	1°	poor
5	Warner	19	10.50	82	43	"	S.	13.65	1°	
6	"	"	11.00	82	43	"	S.	12.06	1°	
7	"	"	11.15	83	42	"	S.	11.50	1°	
9	"	"	11.45	83	42	"	S.	11.64	1°	hard
11	"	"	1.30	85		"	S.T.	10.60	1	hard
16	"	"	3.30	80	48	"	S.	13.67	1°	hard
17	New Dayton	20	9.50	78	51	"	S.	10.37	1°	
18	" "	"	10.00	78	51	"	S.	11.66	1°	
19	" "	"	10.20	79	47	"	S.T.	12.20	1°	
20	Stirling	"	11.00	81	42	"	S.	12.84	1°	
21	"	"	11.10	81	42	"	S.	10.32	1°	hard
22	"	"	11.45	83	39	"	S.	11.98	3°	
23	Kipp	"	2.30	82	40	"	S.T.	11.54	1°	
25	Coalhurst	"	2.45	83	40	"	S.	11.46	1°	
29	"	"	3.00	81	39	"	S.	12.82	2°	
30	"	"	4.15	77	44	"	S.	11.94	2°	
26	Monarch	"	5.30	72	47	"	S.	11.88	1	hard
24	Macleod	22	9.00	70	54	A.R.W.	S.	14.96	1	A.R.W.
27	"	"	9.15	70	54	"	S.	13.59	1	hard
28	"	"	9.25	70	54	Marq.	S.	14.45	1	hard
31	"	"	10.00	71	56	"	S.	13.28	1	hard
33	"	"	10.15	71	56	A.R.W.	S.	11.51	1	A.R.W.
34	"	"	10.30	71	56	"	S.	13.68	2	A.R.W.
35	"	"	1.40	73	49	Marq.	S.	12.70	1	hard
43	"	"	2.00	73	49	A.R.W.	S.	12.12	2	A.R.W.
44	"	"	2.30	72	50	"	S.	12.26	2	A.R.W.
46	"	"	2.45	72	50	Marq.	S.	17.05	Sample Grade Heated & Musty	
47	"	"	3.15	70	54	"	S.	13.15	1	hard

Table XVIII

Moisture and grade of wheat harvested in Alberta after one rain by different methods.

(S.= straight combine; S.C.= swath & combine; S.T.= stook threshed)

Lab. No.	Place	Date	Time	Temp. °F.	Rel. Hum.	Variety	Harvesting Method	Moisture	Grade
45	Nobleford	Aug. 23	9.00	78	45	Marq.	S.C.	14.5	1°
42	"	"	9.00	78	45	"	S.	12.42	1°
55	"	"	9.20	77	46	"	S.	12.08	2°
56	"	"	9.30	77	46	"	S.	12.43	1°
57	"	"	9.50	78	45	"	S.	13.56	1°
58	"	"	10.15	78	45	"	S.	10.34	1°
59	"	"	10.30			"	S.T.	10.22	1 hard
60	"	"	10.50	84	32	"	S.C.	13.19	1 hard
51	"	"	11.10			R.Bobs	S.	14.07	1°poor
53	"	"	11.20	84	32	"	S.	16.82	Sample Grade heated & musty
54	"	"	11.55	85	30	"	S.	14.27	1°
61	Barons	"	13.40	86	28	Marq.	S.T.	11.31	1°
62	"	"	13.55	86	28	"	S.	11.92	1 hard
63	"	"	14.20			"	S.	13.50	1°
64	"	"	14.40			"	S.	10.40	2°
65	"	"	14.50			"	S.	12.96	1 hard
66	"	"	15.30	77	38	"	S.	12.20	1 hard
67	"	"	15.40			"	S.	16.81	Sample grade heated & musty
68	"	"	16.00			"	S.	11.59	1 hard smutty
69	"	"	16.30			"	S.	10.98	1°
70	"	"	16.45	74	43	"	S.	11.31	1°
80	"	"	16.55			"	S.	17.40	1 hard
82	"	"	17.30			"	S.	10.80	1 hard
83	"	"	17.50			"	S.	15.68	1°Tf. smutty
84	"	"	18.15			"	S.	17.00	1° smutty

Table XIX

Moisture and grade of grain harvested in Alberta after two rains by different methods

(S.C.= swathed & combined; S.T.= stook threshed; S.= straight combined, H.B.= header barge)

Lab. No.	Place	Date	Time	Temp. °F.	Rel. Hum.	Variety	Harvesting Method	Moisture	Grade
		Sept.							
85	Clover Bar	1	5.00	59	33	Reward	S.	15.52	2°
105	"	10	9.30	61	37	Marq.	S.	14.16	1°
106	"	"	14.00	68	31	"	S.	14.62	1°
107	"	"	16.00	70	32	"	S.	14.50	1°
108	"	"	20.00	54	47	"	S.	13.30	1°
109	"	"	20.00			"	S.	14.55	1°
110	"	"	20.00			"	S.	14.45	1°
111	"	12	9.30	46	55	"	S.C.	12.44	1°
112	"	"	13.30	55	38	"	S.C.	11.73	1°
113	"	"	16.00	57	36	"	S.C.	12.85	1°
114	"	"	18.00	54	38	"	H.B.	13.33	1°
115	Irricana	14	15.00	67	32	Garnet	S.T.	11.69	1°
116	"	"	15.10			"	S.C.	12.55	1 hard
118	"	"	15.30			"	S.C.	14.75	2° garnet
119	"	"	16.00			Marq.	S.T.	11.51	1 hard
120	"	"	16.20	65	33	Garnet	S.T.		2° garnet
135	"	"	17.00			Marq.	S.C.	12.30	1 hard
134	Cayley	15	14.00	71	22	R.Bobs	S.C.	12.88	3°
136	"	"	14.30	71	22	Marq.	S.T.	12.67	1°
133	"	"	14.40	71	22	"	S.C.	12.88	1°
137	"	"	14.55	71	22	"	S.T.	12.25	1°
138	"	"	15.15	71	22	"	S.T.	14.10	3°
139	Nanton	"	15.40	64	24	"	S.C.	11.12	1°
140	Cayley	"	16.00	64	24	Bobs 222	S.C.	12.00	2°
141	"	"	16.20	64	24	" "	S.T.	11.24	1 hard
142	Nanton	"	16.40	64	24	Marq.	S.C.	11.57	1°
143	Cayley	"	17.00	63	26	"	S.C.	12.71	2°
144	"	"	17.20			"	S.T.	11.44	1°
145	Nanton	"	17.30			"	S.T.	11.08	1° smutty
146	"	"	17.45	63	26	"	S.T.	10.76	1 hard
147	"	"	17.50	63	26	"	S.	12.33	2°
148	"	"	17.55			"	S.	13.32	2° poor
149	"	"	18.00			"	S.T.	10.63	1 hard
150	"	"	18.00			"	S.T.	9.97	1°
151	Parkland	16	9.00	59	39	"	S.C.	10.39	1 hard
152	Nanton	15	19.30	61	33	"	S.T.	10.10	1 hard
153	Parkland	16	9.10	59	39	"	S.C.	10.42	1 hard
154	"	"	10.30	64	34	"	S.	11.30	3° frost
155	"	"	11.15	64	32	R.Bobs	S.T.	10.30	1 hard
156	Nanton	15	20.40	58	39	Marq.	S.	13.13	1°
157	Claresholm	16	16.00	70	32	"	S.C.	10.32	1° smutty
158	"	"	16.30	70	32	"	S.T.	9.88	1 hard
159	"	"	16.45	70	32	"	S.T.	9.35	1°
160	"	"	17.00			"	S.	10.13	1°

Lab. No.	Place	Date	Time	Temp. °F.	Rel. Hum.	Variety	Harvesting Method	Moisture	Grade
		Sept.							
161	Claresholm	16	17.30			Marq.	S.T.	9.88	1°hard
162	"	"	17.35			"	S.	15.68	1°
163	"	"	18.00	66	34	"	S.T.	9.60	1 hard
164	"	"	15.00	75	23	"	S.	10.68	1 hard
165	"	"	15.10	75	23	Kitchener	S.	11.88	2°
166	"	"	15.25	75	23	Marq.	S.	12.55	1°smutty
167	"	"	15.40	75	25	"	S.T.	10.45	1 hard
168	"	"	15.45			"	S.C.	10.94	1°
169	"	"	16.00	70	32	"	S.C.	11.91	1 hard
170	Barons	17	14.45	77	22	"	S.	10.67	2°
171	"	"	15.00	77	22	"	S.	10.65	2°
172	"	"	15.15	77	22	"	S.T.	11.51	1°
173	"	"	15.30	79	20	"	S.T.	9.32	1°
174	"	"	15.50	79	20	"	S.C.	11.53	1°
175	"	"	16.00	77	22	"	S.T.	9.62	1°
176	"	"	16.10			"	S.T.	11.44	2°
177	"	"	16.30	77	22	"	S.	16.67	Sample grade Heated & Musty
178	Carmangay	19	10.00	62	38	"	S.T.	11.88	1°smutty
179	"	"	10.15	62	38	"	S.	12.93	1°poor
180	"	"	10.25			"	S.T.	10.53	1 hard
181	"	"	10.40			"	S.	14.21	2°
182	"	"	10.50			"	S.	11.26	2°poor
183	"	"	11.15	61	39	"	S.	10.96	2°
184	"	"	11.30			"	S.	12.15	3°
185	"	"	11.45			"	S.	11.34	1 hard
186	"	"	12.00	58	48	"	S.T.	10.77	1°
187	"	"	12.15	58	48	"	S.	12.23	2°
188	"	"	13.50	57	48	"	S.T.	12.33	1 hard
189	"	"	14.15	57	48	"	S.T.	14.81	1 hard
190	Champion	"	16.00	56	52	"	S.	11.68	1 hard
191	"	"	16.00			"	S.	12.52	2°
192	"	"	16.15			"	S.	12.00	2°
193	"	"	16.30			"	S.T.	11.05	1 hard
194	"	"	16.50	56	52	"	S.	11.67	2°
195	"	"	17.00			"	S.T.	10.73	1 hard
196	"	"	17.15			"	S.	10.82	2°
197	"	"	17.25	57	50	"	S.T.	10.91	1°
198	Vulcan	20	8.30	72	47	"	S.	11.86	1 hard
199	"	"	8.40	72	47	Red Bobs	S.	12.27	2°
200	"	"	8.55	72	47	Marq.	S.	12.03	3°
201	"	"	9.20	72	47	Red Bobs	S.	14.63	2°
202	"	"	9.35	72	47	Marq.	S.T.	12.51	1°
203	"	"	10.00	72	47	"	S.	13.41	1°
204	"	"	10.15			"	S.C.	12.01	1°
205	"	"	10.30			"	S.T.	11.68	1°
206	"	"	10.50	74	45	"	S.C.	12.20	1°
207	"	"	11.00	75	44	"	S.T.	12.82	1°
208	"	"	11.15			"	S.	11.56	1°
209	"	"	11.40	72	47	"	S.T.	13.57	3°

Lab. No.	Place	Date	Time	Temp. °F.	Rel. Hum.	Variety	Harvesting Method	Moisture	Grade
		Sept.							
210	Vulcan	20	11.50	72	47	Marq.	S.	11.90	1°
211	"	"	12.10	72	46	Reward	S.C.	11.90	1 hard
213	Oyen	22	15.00	64	33	Marq.	S.	14.58	1°
214	"	"	15.10	64	33	"	S.T.	13.57	3°
215	"	"	15.30			"	S.T.	14.11	2°
216	"	"	15.50			"	S.T.	12.56	1 hard
217	"	"	16.20			"	H.B.	11.74	1°
218	"	"	16.25			"	H.B.	12.45	1°
219	"	"	16.50	62	37	"	S.	13.21	2°
220	"	"	17.00	62	37	"	S.	11.27	1°
221	"	"	17.15	62	37	"	S.T.	12.25	1°
222	"	"	17.30	61	37	"	S.	13.02	1°
223	"	"	18.30	54	42	"	H.B.	13.67	1°
224	"	"	18.50	52	42	"	H.B.	12.04	1 hard
225	"	"	19.15	54	42	"	S.	17.80	sample grade heated & musty
226	"	23	9.40	61	44	"	S.	16.47	3° smutty
227	"	"	11.00	65	37	"	H.B.	13.92	2°
228	Naco	24	10.30	52	69	"	S.	16.36	2°
229	"	"	10.45	52	69	Renfrew	S.T.	12.81	2°
230	"	"	11.00	52	69	Marq.	S.T.	10.94	1°
231	"	"	11.40	50	71	"	H.B.	12.41	1°
232	"	"	11.50			"	S.	12.62	1°
233	"	"	12.10	50	71	"	S.T.	11.17	1°
234	Cereal	"	14.30	53	65	"	S.T.	11.96	1 hard
235	"	"	15.00			"	S.T.	13.04	1°
237	"	"	15.10			"	S.	10.80	2°
238	"	"	15.30			"	S.	11.81	1 hard
239	Hanna	"	18.40	50	75	"	S.	12.46	2°
240	"	"	18.50	50	75	"	S.T.	13.41	1°
241	"	"	18.55	50	75	Garnet	S.	13.31	3°
242	"	"	19.15	50	75	Marq.	H.B.	12.74	1°
243	"	"	19.20	50	75	"	S.T.	12.27	1°
244	"	"	19.30	50	75	"	S.	11.97	1°
245	Beiseker	26	14.30	61	35	"	S.	13.80	3° smutty
246	"	"	14.45	61	35	"	S.T.	13.79	1°
247	"	"	15.10	61	35	Garnet	S.T.	12.75	2°
248	"	"	15.30	61	35	Marq.	S.T.	12.64	4°
249	"	"	15.40			Garnet	S.C.	12.57	2°
250	Three Hills	"	16.00	59	36	Marq.	S.C.	12.30	2°
252	"	"	16.15	59	36	Garnet	S.T.	12.18	2°
253	"	"	16.40			"	S.C.	12.88	2°
254	"	"	17.15			Marq.	S.T.	12.34	1°
270	"	"	18.00			"	S.	13.77	5°

Table XX

Wheat samples collected before rain - classified as to method of harvesting, moisture and grade.

Moisture Range Straight Grade	Stook Threshed — No. of Samples Grading						Straight Combined — No. of Samples Grading						
	1 Hd.	1°	2°	Tot.	Moist. Aver.	Grade Aver.	1 Hd.	1°	2°	3°	Tot.	Moist. Aver.	Grade Aver.
Less than 10.8	1			1	10.60	0.0	1	1			2	10.34	0.5
10.9 - 11.7		1		1	11.54	0.1		5			5	11.55	1.0
11.8 - 12.6		1		1	12.20	0.1	1	1	3	1	6	12.04	1.66
12.7 - 13.5							4	1	1		6	13.06	0.5
13.6 - 14.4							2	2	1		5	13.87	0.8
	1	2		3	11.44	0.66	8	10	5	1	24	12.43	0.79
Tough													
14.5 - 15.3								1			1	14.96	1.0
15.4 - 16.2													
16.3 - 17.0							Sample Grade				1	17.05	7.0
Total Tough							Heated & Musty				2	16.00	4.0
Entire Series	1	2		3	11.44	0.66	8	11	5	Sample Grade 1	26	12.71	1.03

Note: No swath and combine samples were obtained before rain.

Table XXI

Wheat samples collected in Alberta after one rain - classified as to methods of harvesting, moisture and grade

sture Range aight Grade	Stook Threshed						Straight Combined							Swath and Combine					
	# Samples Grading			Sample		Moist	Grade	# Samples Grading			Sample		Moist	Grade	# Samples Grading			Sample	Moist	Grade
	1 Hard	1°	2°	Grade	Total	Aver.	Aver.	1 hd.	1°	2°	Grade	Tot.	Aver.	Aver.	1 hd.	1°	2°	Grade Tot.	Aver.	Aver.
s than 10.8%	1				1	10.22	0.0	1	1	1		3	10.51	1.0						
0.9 - 11.7		1			1	11.31	1.0	1sm.	2			3	11.29	0.66						
1.8 - 12.6								2	2	1		5	12.10	0.8						
2.7 - 13.5								1	2			3	13.34	0.66	1			1	13.19	0.0
3.6 - 14.4									2			2	14.17	1.00						
al Straight	1	1			2	10.76	0.5	5	9	2		16	12.17	0.81	1			1	13.19	0.0
gh-14.5 - 15.3																1		1	14.50	1.0
15.4 - 16.2																				
16.3 - 17.0									.2sm.		2 heated & musty	4	16.57							
al Tough									2		2	4	16.57	4.0						
p 17.1 - 17.9									1			1	17.40	1.0						
al Damp									1			1	17.40	3.4						
ire Series	1	1			2	10.76	0.5	5	12	2	2	21	10.89	1.4	1	1		2	13.84	0.5

TABLE XXII

Wheat samples collected in Alberta after 2 rains - classified as to method of harvesting, moisture and grade.

sture Range	Stook Threshed								Straight Combined								Swath & Combine								Header Barge							
	No. Samples Grading					Moist Grade			No. Samples Grading					Sample	Moist Grade		No. Samples Grading				Moist Grade				No. Samples Grading				Moist Grade			
aight Grade	1 hd.	1°	2°	3°	4	Tot.	Aver.	Aver.	1 hd.	1°	2°	3°	5	Grade	Tot.	Aver.	Aver.	1 hd.	1°	2°	3°	Tot.	Aver.	Aver.	1 hd.	1°	2°	3°	Tot.	Aver.	Aver.
s than 10.8%	10	5				15	10.12	0.33	1	1	4				6	10.62	1.5	2	1			3	10.37	0.33							
0.9 - 11.7%	3	8	2			13	11.33	0.92	2	2	3	1			8	11.38	1.12		5			5	11.37	1.0		1		1	11.74	1.0	
1.8 - 12.6%	3	7	1		1	12	12.32	1.08	2	4	7	2			15	12.10	1.6	4	3	3		10	12.21	.9	1	2		3	12.30	0.66	
2.7 - 13.5%		3	2	2		7	13.13	1.85		5	2	1			8	13.20	1.5		2	2	1	5	12.85	1.8		2		2	13.03	1.00	
5 - 14.4%		1	1	1		3	14.00	2.00		2	1	1	1		5	14.07	2.8									1	1	2	13.79	1.5	
al Straight	16	24	6	3	1	50	11.90	0.98	5	14	17	5	1		42	12.19	1.61	6	11	5	1	23	11.93	1.04	1	6	1	8	12.78	0.87	
gh 14.5-15.3%	1					1	14.81	0.0		4	1				5	14.57	1.2			1		1	14.75	2.00							
5.4 - 16.2										1	1				2	15.60	1.5														
5.3 - 17.0											1	1		1	3	16.50	4.0														
al Tough	1					1	14.81	0.0		5	3	1		1	10	15.35	2.1			1		1	14.75	2.00							
17.1-17.9%														1	1	17.80	7.0														
al Damp														1	1	17.80	7.0														
re Series	17	24	6	3	1	51	11.68	.96	5	19	20	6	1	2	53	12.90	1.81	6	11	6	1	24	12.04	1.08	1	6	1	8	12.78	0.87	

permit a comparison of the effect of exposure to rainfall and method of harvesting on grade, it was suggested that arbitrary numerical values be assigned to the inspector's grades. The values assigned to 1 hard, 1°, 2°, 3°, 4°, No. 5, were as follows 0, 1, 2, 3, 4 and 7.

In the survey, 5 samples of sample grade combined wheat were collected and these are given a numerical value of 7 the same as for No. 5. It was thought that at the prevailing low prices this would bring about the same amount of money as No. 5 would for pig feed. Actually the valuation was low but as the number of samples concerned was small it did not affect the general result very seriously.

Discussion

Moisture and grade. - By referring to Table XIX which gives the classifications of the samples collected before rain, it will be noted that the average moisture content of the wheat samples was 11.44%, and 12.71% for the stook-threshed and straight combined samples respectively. No swath and combine samples were obtained previous to being exposed to rain. The average grades for the stook-threshed and straight combined grain collected before rain were 0.66 and 1.03 respectively. In this group exposure to rain is not a factor affecting the moisture content and differences are due entirely to the farmer's own judgment as to the proper time to thresh the grain. The data obtained shows that even under favorable weather conditions a higher moisture content may be expected in straight combined grain than in stook threshed grain, although in this particular case the number of stook-threshed samples was too small to have much significance. However, a glance at Tables XXII and XXIII will show that even after one and two rains, the stook-threshed samples had a lower average moisture than the straight combined samples gathered before

Table XXIII

Common Wheat.

Summary of moisture and grade survey.

Method of Harvesting	No. Samples Collected.	Percentage of Samples Grading Straight	Tough	Damp	Moisture. Min.	Max.	Aver.	1 Hard	1°	2°	3°	4	5	Sample Grade	Grade Aver.
Stook Threshed															
Before Rain	3	100			10.60	12.20	11.44	33½	66½						0.66
After 1 Rain	2	100			10.22	11.31	10.76	50	50						0.5
After 2 or more rains	51	98.2	1.8		9.32	14.81	11.68	32.6	45.6	14.2	6.5	2.1			0.96
Straight Combined.															
Before Rain	26	92.3	7.6		10.32	17.05	12.71	30.6	42.3	19.2	3.8			3.8	1.03
After 1 Rain	21	76.19	19.0	4.7	10.34	17.40	10.89	23.8	57.1	9.5				9.5	1.40
After 2 or More Rains	53	79.2	18.8	1.8	10.13	17.80	12.90	9.4	35.8	37.7	11.3	1.8		3.7	1.81
Swath & Combined															
After 1 Rain	2		50	50	13.19	14.50	13.84	50	50						0.5
After 2 or More Rains	24	95.8	4.1		10.32	14.75	12.04	25	45.8	25	4.2				1.08
Header Barge															
After 2 or More Rains	8	100			11.74	13.92	12.98	12.5	75	12.5					0.87
Entire Series	190														

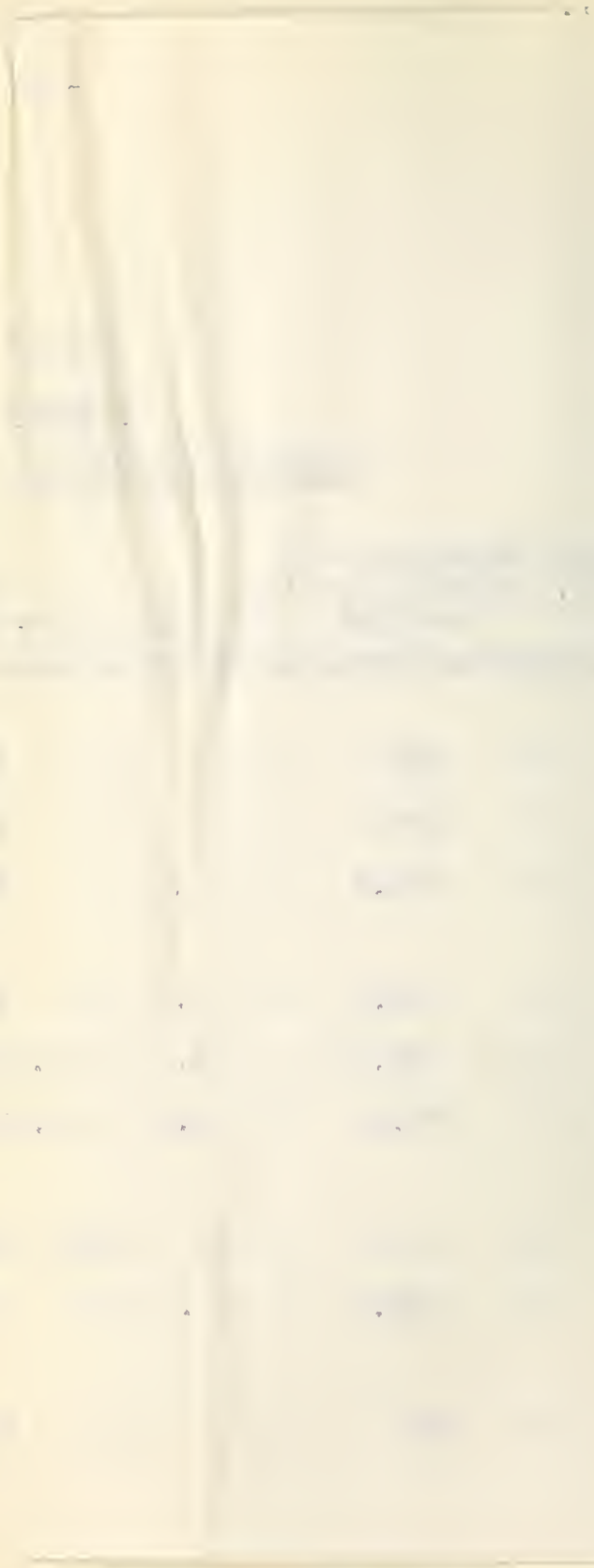


Table XXIV

Rainfall recorded at dominion meteorological stations during period of moisture and grade survey.

Precipitation in last 24 hours (7 a.m. to 7 a.m.)

ate	Lethbridge	Macleod	Raymond	Cardston	Claresholm	Vulcan	High River	Calgary	Strathmore	Three Hills	Hanna	Naco	Sibbald	Edmonton
	inches													
ug.17	.20	-	.11	-		-	-	-	Trace	-	-	-	-	-
18	.24	-	-	-		-	-	Trace	Trace	.07	-	-	-	-
19	.04	-	-	-		-	-	Trace	.14	-	.16	-	.23	-
20	-	-	.06	-		.25	-	.18	-	.81	-	-	-	-
21	.68	.74	1.42	-		.27	-	-	-	-	.82	.70	-	-
22	.51	.15	.02	.45		-	-	-	Trace	-	-	-	.80	-
23	.09	.03	.04	.04		.21	-	.10	.52	-	.01	.04	-	-
24	-	.10	.21	.02		.08	2.69	Trace	-	-	-	-	-	.14
25	-	.05	-	.05		-	-	-	-	-	--	-	.11	-
26	-	-	-	-		.10	-	-	-	-	-	-	-	Trace
27	-	-	-	-		-	-	-	-	-	-	-	-	-
28	.02	-	.28	.02		.06	-	-	.18	-	.03	-	-	Trace
29	.14	.04	-	-		.05	1.14	.22	1.14	.23	-	.11	.31	-
30	.14	-	.07	.06		.99	-	.48	.02	.02	.01	-	-	Trace
31	-	.11	-	-		-	-	-	-	-	-	-	-	.01
ept.1	.16	-	.06	-		.02	.04	Trace	Trace	-	-	-	-	.02
2	-	.02	-	-		-	-	-	-	-	-	-	-	.01
3	-	-	-	-		-	-	-	-	-	-	-	-	-
4	-	-	-	-		-	-	-	-	-	-	-	-	-
5	-	-	-	-		-	-	-	-	-	-	-	-	-
6	-	-	-	-		-	-	-	-	.44	-	-	-	-
7	-	-	-	-		-	-	-	-	-	-	-	-	-
8	.04	-	.02	-		.40	.04	.48	.25	-	-	-	-	.13
9	-	.05	-	-		-	-	-	-	-	1.35	1.00	2.00	-
10	-	-	-	-		-	-	-	-	-	-	-	-	-
11	.04	-	-	Trace		.41	-	.10	.10	.18	-	-	-	Trace
12	-	-	-	-		-	-	-	-	.04	-	-	-	-
13	-	-	-	-		-	-	-	-	-	-	-	-	Trace
14	-	-	-	-		-	-	-	-	-	-	-	-	-
15	-	-	-	-		-	-	-	-	-	-	-	-	-

No Report

Date	Lethbridge	Macleod	Raymond	Cardston	Claresholm	Vulcan	High River	Calgary	Strathmore	Three Hills	Hanna	Naco	Sibbald	Edmonton
Sept.16	-	-	-	-	.05	-	-	-	-	-	-	-	-	-
17	-	-	.03	-		-	-	-	.70	.30	-	-	-	.16
18	-	-	.23	Trace		1.01	-	.41	.29	.68	.21	.22	-	.56
19	-	.02	-	-		.11	-	.06	-	.09	-	.16	-	.02
20	.31	-	-	Trace		-	.19	Trace	-	-	.07	-	-	.08
21	-	-	-	-		-	-	-	-	-	-	-	-	-
22	-	-	-	.09		-	-	-	-	-	-	-	-	-
23	-	-	-	-	.06	-	-	-	-	-	-	-	-	-
24	.07	-	.03	Trace	-	.06	-	.16	.18	.13	.09	-	-	-
25	-	.05	.12	Trace	-	.20	-	-	Trace	-	-	.25	.25	-
26	-	-	-	-	-	-	.26	-	-	-	-	-	-	-
27	-	-	-	-	-	-	-	-	-	-	-	-	-	-
28	-	-	-	-	-	-	-	-	-	-	-	-	-	-
29	-	-	-	-	-	-	-	-	-	-	-	-	-	-
30	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Oct. 1	-	-	-	-	-	-	-	-	-	-	-	-	-	.01
2	.19	-	.21	-	-	-	.12	-	.20	-	-	-	-	-
3	-	.10	-	-	-	-	-	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5	-	-	.04	-	-	-	-	-	.35	-	-	-	-	Trace
6	31"snow	.08	.25	4"snow	24"snow	.20	-	8"snow	-	.21	-	-	-	-
7	-	-	2"snow	-	-	.05	9"snow	-	3"snow	-	-	-	-	-
Total	3.09"	1.55"	3.20"	.74	2.11	4.47	4.49	2.24	4.42	3.20	2.75	2.48	3.70	1.14

the exposure to rainfall. It will also be noticed that two of the straight combined samples in Table XXI were tough and one of these was bordering on being damp.

Moisture and grade after rain. - Of the samples collected after exposure to one rain the average moisture content was 10.76%, 10.89%, and 13.84% respectively for stook-threshed, straight combined, and swath and combined grain. Taken in the same order, the average grades were 0.5, 1.4 and 0.5. The number of stook-threshed and swathed samples in this case was too small to have any significance, there being only two of each. A slight depreciation in grade is noticed between the straight combined samples harvested before and after one rain the former having an average grade of 1.3 and the latter 1.4. The most interesting relationship is that of the moisture contents. Grain combined before rain had an average of 12.71 moisture while that combined after one rain averaged 10.89. Of the samples harvested before rain 92.3% graded straight and 7.6% tough while after one rain 76.19% were straight, 19% tough and 4.7% damp. These data would seem to indicate the presence of quite a number of operators who were either too impatient or whose judgment of the fitness of the grain was poor.

Moisture of samples collected after two rains. - In Table XXII the data for 136 samples gathered after two or more rains is summarized. From this it will be observed that all of the stook-threshed samples, except one graded straight, a percentage of 98.2% to 1.8%. Of the straight combined samples, 79.2% were straight grade, 18.8% tough, and 1.8% damp. 95.8% of the swathed samples graded straight and 4.1% tough. These samples were gathered after an interval of nearly three weeks, during which time they

had been exposed to heavy rains. This delay had the effect, in most cases, of removing one of the important sources of trouble, namely, uneven ripening, because during the interval most of the grain had become fully mature and most of the green weeds had ripened too, hence most of the tough and damp samples must be attributed either to the impatience or poor judgment of the operator.

The average moisture for the four methods was, stook-threshed 11.68%, straight combined 12.90%, swath and combined 12.04%, and header barge 12.78%. From this it will be noted that the average moisture content of the straight combined samples was 1.22% higher than for the stook-threshed samples. Weather conditions during this period of collection were quite favorable and threshing by all methods was in full progress. Many fields of unthreshed swathed grain were examined during this period of collection and observations showed a great deal of damage done through bleaching, sprouting, and scattering by the wind. Heavy wet snow soon after this date (Sept. 26th) forced a lot of the swathed grain down through the stubble and on to the ground, and had it been possible to gather samples late in the fall severe deterioration in grades would have been apparent.

Effect of two or more rains on grade. - The commercial grades of samples collected after two or more rains are shown in Table XXII. From this it will be noted that the average grades were .96, 1.81, 1.08, and .87 for the stook-threshed, straight combined, swath and combined, and header barge samples respectively. In other words, from the standpoint of grades the header barge ranked first, stook-threshed second, swath and combined third and straight

combine fourth. However, the number of barge samples was too small to be of much significance.

In Table XXIII, the grades and moisture contents of all samples are summarized and from this it will be seen that the majority of samples collected from all methods of harvesting fell within the first four grades. The number of stook-threshed samples gathered before rain was too small to be of any significance in comparing them with the straight combined samples. The same was true of both stook-threshed and swath and combined samples after one rain so the main comparison must be made after two or more rains. However, it is interesting to note the constant decrease in the number of samples grading 1 hard in the straight combined grain as it was exposed to rain. Before rain 30.6% graded 1 hard, 42.3% 1 Northern and 10.2% 2 Northern. After one rain the number grading 1 hard was reduced to 23.8% and 1 Northern increased to 57.1%. After two or more rains the number of samples grading 1 hard was reduced to 9.4%, those grading 1 Northern reduced to 35.8% and those grading 2 Northern increased to 37.7%.

In comparing the four methods of harvesting the stook-threshed samples showed the least depreciation as a result of exposure to rain, having 32.6% graded 1 hard as against 9.4%, 25% and 12.5% for the straight combine, swath and combine, and header barge respectively.

In summarizing the results of effect of rain on the grade of all samples as harvested by the four methods and shown in Table XXIII it will be noted that grades decreased progressively regardless of the method, with exposure to rain, but this depreciation was least in the stook-threshed samples and greatest in the straight

combine samples. The swath and combine samples occupying an intermediate position between the two. As was pointed out before however, there is ample reason for belief that if more swath and combine samples had been gathered after the storm of September 26th a different relationship would have been shown between the latter and the straight combine samples. Elevator men who were interviewed after this time stated that no swath and combine samples received subsequent to September 26th graded above 3 Northern. One possible explanation of the comparatively high grade of swath and combine samples after two or more rains is that a number of them were taken in elevators and some of these may have actually been harvested before rain or after one rain although collected after two or more rains.

Wide observation in the field by the writer supported by evidence of many elevator operators leaves no doubt of the fact that swath and combined grain deteriorates and sustains more loss under adverse weather conditions than grain standing in the field. This is also in agreement with the work of Geddes in Manitoba and reported by Larmour, Geddes and Cameron (16).

Conclusions

The moisture and grade survey of 1932 showed that even under conditions where rain was not a factor 7.6% of the straight combined samples graded tough, hence the fault in this case must be attributed to the judgment of operators who were either unable to properly gauge the actual moisture content or did not make sufficient allowance for the effect of green spots and green weeds in the field.

The average moisture content of straight combined grain is higher than that of grain harvested by other methods even under favorable conditions hence it appears reasonable to expect that under more unfavorable circumstances the percentage of tough and damp samples would be much larger.

The grade of grain harvested by the combine after exposure to rain will be depreciated more than that of comparable grain threshed from the stook.

GENERAL SUMMARY

In summarizing the studies reported in this paper it might be well for the sake of clarity to list them in order and then proceed to review the results and conclusions arrived at as a result of the investigation. The studies made during the harvest seasons of 1931 - 32 and - 33 reported herewith are:

1. (a) A Comparison of Harvesting Methods in Relation to Quality of Wheat and Barley During Fall of 1931.

   (b) A study on the over-wintering of barge stacks.

   (c) A comparison between the harvesting losses resulting from the barge and binder methods.

2. Comparison of Harvesting Methods and Their Effect on Quality of Wheat, 1932.

3. Comparison of Harvesting Methods and Their Effect on Quality of Wheat, 1933.

4. A Comparison of Various Harvesting Methods in Respect to Moisture and Grade of Grain.

As each of the above investigations has been discussed in detail previously, the purpose of this concluding summary will be to bring together the findings and present the general picture of "Harvesting Methods in Relation to Quality in Wheat." Covering as they do a period of three years the studies were carried out under a fairly normal cross-section of harvesting conditions as they exist in the province of Alberta from year to year. The fall of 1931 was one in which more wet weather than usual was experienced, but would not be described as a bad fall. The harvest season of 1932 in the Edmonton district was practically ideal while that of 1933 was decidedly bad both from the standpoint of the amount of actual rainfall, and high humidity combined with low temperatures.

In 1931 the study was limited to a comparison of the effect of the binder and barge methods on the commercial grades of wheat and barley. The results showed that the grain was given the same grade from both methods although the barge samples were superior within the limits of the grade, mainly on account of greater uniformity and better color. In 1932 the straight combine, swather and combine, binder, and header barge methods were compared under very favorable conditions and the results indicated a slight superiority in the barge samples when judged from the standpoint of weight per bushel and commercial grade. The binder samples, probably as a result of sampling error, were lower in protein than the samples obtained from the other methods, and the milling and baking data paralleled the protein results without any other significant differences being indicated.

The 1933 results as far as the binder and barge methods were concerned, were almost the exact opposite of those of 1932, the binder samples being superior in quality to the barge samples in every respect. From the results obtained in these studies it is evident that differences in quality of wheat harvested by the two methods are due (1) to the effect of differences in weather conditions and (2) differences in moisture content at time of harvesting. In 1931 barge stacks of mature grain were exposed to 2.63 inches of rain, humidity was high, and many were placed on damp ground, yet the quality of the samples from the standpoint of grade was equal to or better than that of binder samples exposed to similar conditions. Again, in 1932 grain of comparatively low moisture content cured rapidly in stacks and produced a superior quality of grain to that harvested

by other methods. In 1933, with a combination of wet weather, damp ground, and high moisture content of grain at time of cutting, barge stacks required a longer period to dry down to 14% moisture than grain harvested by other methods, and the threshed sample was inferior in grade and milling and baking quality. From these results it may be concluded that (1) when weather and crop conditions are similar to those prevailing in 1931, well-matured grain can be barged with safety. (2) Whenever and wherever conditions similar to those of 1932 prevail, grain harvested by the barge method will be of high quality, and (3) when conditions are comparable to those of 1933 the method cannot be recommended in the Edmonton district.

Stage of maturity and moisture content at time of cutting are very important factors in the proper curing of barge stacks in the northern park belt districts. Under normal conditions barge stacks will require a longer time to dry down to 14% moisture than grain harvested by other methods, and if weather conditions are unfavorable the length of time required may be considerably longer than for the other methods. On the other hand mature grain (under 25% moisture) may be barged and carried over winter and threshed in the spring without loss of grade if the stacks are properly made and topped.

Under favorable harvest conditions milling and baking results were not significantly different as between the various methods. Under unfavorable harvest conditions the binder samples were somewhat superior to those harvested by other methods and it would seem reasonable to conclude that this result is the one most commonly found when harvest-

ing conditions are compared under the more humid park belt conditions. Harvesting losses were significantly less with the header barge method than with the binder.

Although the study was too limited to base definite conclusions on the results, the storage experiment on combined grain indicated that there was no danger of it heating under Edmonton conditions when put in the bin at 14.5% moisture.

The results of the moisture and grade survey carried out in the fall of 1932 in Alberta indicated that grain harvested by the straight combine method always had a higher average moisture content than grain harvested with the binder even when rain was not a factor. Of the samples collected before exposure to rain 7.6% were graded tough and the average in the three western provinces for the same survey was 25% tough. The fault in this case must be attributed to the judgment of the operators who were either unable to properly gauge the approximate moisture content of the grain or failed to make sufficient allowance for the effect of green spots and green weeds in the field. From this it would be reasonable to assume that under less favorable harvesting conditions the number of tough and damp samples would be much larger.

Grain harvested by all methods depreciates in grade with exposure to rainfall, but the depreciation is least for binder-harvested grain.

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